Proceedings

EFFECT OF LATE SEASON HERBICIDE APPLICATION SEED PRODUCTION OF GLYPHOSATE-RESISTANT PALMER AMARANTH. J. H. Scarparo de Sanctis*[1], A. J. Jhala[2]; [1]University of Nebraska Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Lincoln, NE (1)

ABSTRACT

Effect of Late Season Herbicide Application on Seed Production of Glyphosate-resistant Palmer amaranth

Jose H.S. de Sanctis, Parminder Chahal, Vipan Kumar, Stevan Knezevic, Amit Jhala

Palmer amaranth (*Amaranthus palmeri*) has become the most troublesome weed in the agronomic crop fields in the United States. A single female Palmer amaranth can produce up to half a million seeds which will replenish soil seed bank for next seasons. Therefore, weed management practices should be focused on reducing the total seed production of Palmer amaranth in the field. Previous literature and POST herbicide labels indicate that 10-15 cm tall Palmer amaranth plants should be sprayed to obtain the highest weed control. Sometimes growers are not able to spray Palmer amaranth at the labeled plant height due to extreme weather conditions such as strong winds or continuous rainfall at the time of POST applications. Therefore, the objective of this study was to evaluate the effect of different POST herbicide programs on glyphosate-resistant (GR) Palmer amaranth control, seed production, or seed viability when applied at different soybean or Palmer amaranth growth stages in dicamba/glyphosate-tolerant soybean. Herbicide programs consisted of single or sequential POSTapplications of glyphosate, acifluorfen, lactofen, fomesafen + fluthiacet methyl, or dicamba at different soybean growth stages. Palmer amaranth plants were 9, 10.5, 12.5, 28, and 65 cm tall when sprayed at V4, V5, R1, R3, or R6 soybeans growth stages, respectively. Single application of dicamba at 560 g ae ha^{-1}at V4 or R1, or sequential applications at V4 and R1, V4 and R3, V4, R1, and R3 soybean growth stages provided 83 to 99% Palmer amaranth control. In addition, single application of lactofen (220 g ae ha^{-1}) at R1 or sequential application at R1 and R6 growth stages controlled Palmer amaranth 80 to 82%. Diversely, single late season applications of acifluorfen and fomesafen + fluthiacet methyl (420 g of ae/ha and 182 g of ae/ha + 8 g of ae/ha) at R6 and R3 soybean growth stages resulted in 48 and 32% Palmer amaranth control, respectively. Soybean yield and Palmer amaranth seed production data are being analyzed; therefore, those results are not presented in the abstract.

DROPLET SIZE EFFECTS ON ITALIAN RYEGRASS (*LOLIUM MULTIFLORUM*) CONTROL IN MISSISSIPPI CORN (*ZEA MAYS*). M. T. Wesley[1], Z. R. Treadway*[2], J. Ferguson[2], J. A. Bond[3], E. J. Larson[4]; [1]Mississippi State University, MS State, MS, [2]Mississippi State University, Mississippi State, MS, [3]Delta Research and Extension Center, Stoneville, MS, [4]Mississippi State University, Starkville, MS (2)

ABSTRACT

Droplet Size Effects on Preemergence Herbicide Efficacy for Italian Ryegrass *(Lolium perenne ssp. multiflorum)*

Michael T. Wesley, Zachary R. Treadway, Jason A. Bond, Daniel B. Reynolds, Erick J. Larson, J. Connor Ferguson

Glyphosate resistant Italian ryegrass (*Lolium perenne* ssp. *multiflorum*), which was first documented in 2005, has proven to be very problematic in corn (*Zea mays*) production. Italian ryegrass can cause issues with corn planting and also with stand development of a corn crop. The competition that arises between the corn crop and the weed can lead to spotty stands, which lead to lowered yields. Droplet size of spray applications have also shown to have an effect on the efficacy of spray applications.

Experiments were conducted at the Black Belt Branch Experiment Station near Brooksville, MS to compare the efficacy of different herbicides sprayed through different nozzles with regards to ryegrass control in a corn production environment. Italian ryegrass was over-seeded in the entire experiment area prior to corn planting. Treatments were divided with three application timings, four herbicides, and three nozzle types. An untreated treatment was also included, in which ryegrass was over-seeded, corn was planted, and no other activity took place until harvest.

Plots were rated for ryegrass control at 7, 14, 28, and 56 days after herbicide application, and the weed control ratings were converted to percent suppression. Plots were harvested and yield results showed that, across herbicide treatments, the TT 110015 resulted in the highest yield which was 166 bu/A. Of the herbicides tested in this experiment, the combination of pyroxasulfone applied preemergence followed by a January application of clethodim and a February application of paraquat resulted in the highest yields which was 176 bu/a.

Results concluded that droplet size does have an effect on the efficacy of herbicide applications in a corn production environment. An application of pyroxasulfone PRE followed by clethodim followed by paraquat applied using TT 110015 nozzles results in the highest corn yields.

EFFECT OF SOIL-APPLIED HERBICIDE TIMING ON COVER CROP ESTABLISHMENT. J. Calhoun*[1], D. B. Reynolds[2]; [1]Mississippi State University, Starkville, MS, [2]Mississippi State University, Mississippi State, MS (3)

ABSTRACT

Greenhouse trials were conducted in 2018 at the R.R. Foil Plant Science Research Center in Starkville, MS to investigate the timing effect of soil-applied herbicide on establishment of common cover crop species. Flats were prepared with field soil and placed in a greenhouse and subjected to 25/30 C° diurnal temperatures and 12 hour photoperiods. Soil flats were randomly assigned a treatment of herbicide and application timing. Herbicides consisted of fomesafen, pendimethalin, pyroxasulfone, S-metolachlor, acetochlor, dimethenamid, flumioxazin, clomazone, metribuzin, and sulfentrazone at recommended rates by Mississippi State Extension for medium soil types. Application timing consisted of 60, 30, 15, and 7 days before planting (DBP). Treatments were applied using a compressed air track sprayer calibrated to deliver 140 L ha^{-1} using XR11002 nozzles. Evaluations consisted of visual injury every seven days for 28 days and plant biomass 28 DAT. Plant biomass was regressed using R (version 0.98.1091, RStudio Inc., Boston, MA) and the resulting functions were used to estimate the number of days prior to planting that PRE applications resulted in no

more than 10% biomass reduction. Radish crops were most sensitive to applications of flumioxazin with 10% reduction occurring at 31 days before planting (DBP). Radish crops were most tolerant to S-metolachlor with 10% reduction occurring with applications at 20 DBP. Rye crops were the most consistent with respects to sensitivity of herbicide application timing. For pyroxasulfone, fomesafen, flumioxazin, and S-metolachlor, application timings ranged from 30-34 days before planting to cause 10% biomass reduction. Application timings of flumioxazin, pyroxasulfone, fomesafen, and S-metolachlor to cause 10% biomass reduction in *Brachiaria* spp. occurred at 53, 35, 34, and 18 DBP respectively.

EFFECTS OF PESTICIDE SEED TREATMENTS AND TILLAGE ON *AMARANTHUS SPP.*. S. A. Palmer*, R. G. Smith, N. Warren; University of New Hampshire, Durham, NH (4)

ABSTRACT

Seed coatings containing insecticides and fungicides—pesticide seed treatments (PST)—are commonly used in many crops including maize (*Zea mays* L.) and soybean (*Glycine max* (L) Merr.). PST has been demonstrated to have both target and non-target impacts on soil food webs; however, it is unknown whether the ecosystem services soil food webs provide, such as regulation of weed populations, are also altered by PST. Our project seeks to understand the impact of PST on weeds in the Northeastern United States. We are conducting a 4-year field experiment in New Hampshire to evaluate the effects of PST on weeds in a maize-corn rotation. Our treatments include pesticide treated and un-treated crop seeds grown in full-till, strip-till, and no-till systems. Here we present preliminary data on the abundance of *Amaranthus* species in the germinable fraction of the soil seedbank in the year prior to and during the first two years of the experiment, as well as the germinability of *Amaranthus retroflexus* L. seeds overwintered in mesh bags. We found the abundance of *Amaranthus* species in the seedbank was lower in the full tillage treatments in all three years; however, there was no evidence of an effect of PST. Mean germination rates of *A. retroflexus* following overwintering also did not differ between PST treated and untreated plots. Future work will evaluate the entire seedbank and emergent weed community and continue to evaluate PST effects on *A. retroflexus* germinability and the seed coat fungal community using ITS2 metabarcoding.

EVALUATING NATIVE PERENNIAL GRASS TOLERANCE TO INDAZIFLAM TREATMENTS. S. J. Nissen*; Colorado State University, Fort Collins, CO (5)

ABSTRACT

Invasive winter annual grasses, such as *Bromus tectorum* (downy brome), currently occupy up to >22 million hectares in the western United States, with an estimated annual spread rate for *Bromus tectorum* of ~14%. The loss of ecological resilience, biodiversity, and deviation from historic fire regimes from these winter annual grasses have been well documented. Limited viable treatment options exist, but chemical control options with long-term residual soil activity has been stated as an important factor to native regeneration and recovery. Indaziflam, a new herbicide option for invasive winter annual grasses in non-grazed rangeland and natural areas, has been shown to provide long-term residual control of germinating cheatgrass while showing little to no effect on native perennial grass species production. Previous published research has shown no negative impacts from indaziflam treatments to desirable species abundance and biomass, although no published research has evaluated impacts to seed production and viability. A field trial was conducted at the Plants Material Center in Meeker, CO to assess tolerance of 14 desirable perennial grass species to the herbicide indaziflam. Herbicide applications of indaziflam (73 and 102 $g \cdot ai \cdot ha^{-1}$) were made to perennial grasses in August 2017. In August 2018 (1 YAT) vegetative biomass, seed production biomass, and seed viability data were collected to assess any herbicide impacts on the perennial grass species. There was no significant decrease in vegetative or seed production biomass across all 14 perennial grass species in plots treated with indaziflam at both rates compared to the control plots. This data provides critical tolerance information to aid land managers in understanding the effects of this new tool for invasive annual grass control on desirable perennial grasses

HERBICIDE EFFICACY AS INFLUENCED BY SPRAY NOZZLE DESIGN AND WEED DENSITY. M. D. Kramer*[1], Z. K. Perry[2], T. R. Legleiter[3]; [1]University of Kentucky, Lynn, IN, [2]University of Kentucky, Paducah, KY, [3]University of Kentucky, Princeton, KY (6)

ABSTRACT

Herbicide Efficacy as Influenced Spray Nozzle Design and Weed Density

A series of restrictions have been created for dicamba applications due to drift issues. One restriction is the use of low drift nozzles. These nozzles produce extremely coarse and ultra-coarse droplets and minimize the production of driftable fines. An experiment was conducted in 2018 at the University of Kentucky Research and Education Center in Princeton, Kentucky to evaluate herbicide deposition and efficacy on *Eleusine indica*. Specifically, looking at the influence of spray nozzle design and weed density. Dicamba plus glyphosate was applied to 5 to 10 cm tall weeds with Turbo TeeJet (TT11005) nozzle and two drift reduction nozzles approved for dicamba applications: Turbo TeeJet Induction (TTI11005) and Pentair Ultra Lo-Drift (ULD12005). Fluorescent dye (PTSA) was added to the spray solution to evaluate deposition on target leaf surfaces within the soybean canopy. Applications were made with an ATV traveling at 16 kph with an output of 140 L per ha. A $0.25m^2$ quadrant was established in each plot prior to the post-emergence application with *Eleusine indica* weed densities ranging from an average of 6 to 25 plants per quadrant. The data collected from this research has shown that drift reduction nozzles and weed density may not reduce herbicide efficacy on *Eleusine indica* as spray solution deposition was equivalent across nozzle types and weed densities used in this study.

IMPACT OF ADJUVANTS ON QUIZALOFOP ANTAGONISM WHEN MIXED WITH ALS HERBICIDES. C. Webster*[1], E. P. Webster[2], B. McKnight[2], D. C. Walker[2], S. Rustom[2]; [1]Louisiana State University, Baton Rouge, AL, [2]Louisiana State University, Baton Rouge, LA (7)

ABSTRACT

Impact of Adjuvants on Quizalofop Antagonism when Mixed with ALS Herbicides

L.C. Webster, E.P. Webster, B.M. McKnight, D.C. Walker, S.Y. Rustom

Louisiana State University Agricultural Center, Baton Rouge

A study was conducted in 2017 and 2018 at the Research Station near Crowley, Louisiana to evaluate the influence of different adjuvants in overcoming the antagonism of quizalofop when mixed with bispyribac. Plot size was 1.5 by 5.1 m with eight, 19.5 cm drill-seeded rows of ACCase resistant (ACCase-R) (*Oryza sativa* L.) 'PVL01' long grain rice. Imidazolinone resistant awnless red rice (*O. sativa* L.) was broadcast at 50 kg ha^{-1} across the entire research area, and the area was naturally infested with barnyardgrass [*Echinochloa crus-galli* (L.) P. Beauv.]. A BASF supplied crop oil concentrate (COC-BASF), (Dash), a crop oil concentrate (COC-Helena), (Agri-Dex), and a silicon based adjuvant (SBA), (Dyne-A-Pak) were evaluated for their potential to overcome antagonism of quizalofop.

The study was a randomized complete block with a three-factor factorial arrangement of treatments with four replications. Factor A consisted of postemergence (POST) applications of quizaolofop at 0 and 120 g ha^{-1}. Factor B consisted of POST applications of bispyribac at 0 and 34 g ai ha^{-1}. Factor C consisted of no adjuvant, COC-BASF, COC-Helena, or a SBA. All adjuvants were applied at a rate of 1% v v^{-1}. Herbicide applications were applied to the rice at the three- to four-leaf stage. Visual evaluations for this study included barnyardgrass and red rice control at 14 and 28 days after the initial treatment (DAIT). Immediately following the 28 DAIT rating date, a second application of quizalofop was applied at 120 g ha^{-1}. Control data were analyzed using the Blouin's augmented mixed model to determine synergistic, antagonistic, or neutral responses for herbicide mixtures by comparing an expected control calculated based on activity of each herbicide applied alone to an observed control of given herbicide mixtures.

Synergistic interactions were observed at 14 DAIT for red rice control when quizalofop was mixed with bispyribac plus SBA or COC-BASF with an observed control of 92 and 95%, compared with an expected control of 88%, respectively. At 14 DAIT, antagonism of quizalofop for barnyardgrass control occurred when mixed with bispyribac plus COC-Helena, SBA, or COC-BASF with an observed control of 43, 63 and 86%, respectively, compared with an expected control of 95%. Synergistic interactions were observed at 14 DAIT for red rice and barnyardgrass control when quizalofop was mixed with all adjuvants evaluated; however, antagonism of quizalofop was observed when mixed with bispyribac with no adjuvant.

At 28 DAIT, a neutral interaction was observed for barnyardgrass control when quizalofop was mixed with bispyribac plus COC-BASF with an observed control of 91%, compared with an expected control of 97%. However, antagonistic interactions were observed at 28 DAIT for barnyardgrass control when quizalofop was mixed with bispyribac plus COC-Helena or SBA. Neutral interactions were observed at 28 DAIT for all mixtures evaluated for red rice control.

In conclusion, these results indicate that the antagonism of quizalofop when mixed with bispyribac plus COC-BASF at 14 DAIT was overcome at 28 DAIT with a neutral interaction for barnyardgrass control. The addition of COC-BASF into a mixture of quizalofop plus bispyribac provided the most consistent control of red rice with a synergistic and neutral interaction at 14 and 28 DAIT, respectively. These results suggest that incorporating COC-BASF into a mixture of quizalofop plus bispyribac will offer the most beneficial mixture for barnyardgrass and red rice control in the Provisia rice system.

INFLUENCE OF ALTERNATIVE WEED CONTROL OPTIONS ON HOP (*HUMULUS LUPULUS*) PRODUCTION. N. Theisen*, H. Hatterman-Valenti; North Dakota State University, Fargo, ND (8)

ABSTRACT

Hop (*Humulus lupulus* L.) a herbaceous perennial, is a high value crop critical in beer production. Interest to grow hop as niche local market crop have become increasingly popular in areas not known for the crop's culture, such as North Dakota. Little research on hop growth and production techniques in the United States have been conducted outside the Pacific Northwest. Consequently, non-traditional growing areas generally have few chemical options registered for use in hop production. In addition to limited weed control options, there are increased interests for non-chemical weed control methods in organic and low input production systems. These limitations and interests have spurred the need for research on alternative weed control methods such as mulching, and their effect on hop production systems. Field experiments were conducted in 2017 & 2018 at the NDSU Horticulture Research site near Absaraka, ND to evaluate the growth and yield characteristics of three commercial hop cultivars in response to mulch weed control options. Hop cultivars 'Cascade', 'Santaim', and 'Mt. Hood' were grown under landscape fabric, straw much, woodchip mulch, and a non-mulched control in a standard hop trellis system. Plant biomass, plant height, cone dimensions, and yield were taken prior and after mechanical harvest. 'Cascade' had significantly higher yield, cone dimension, and biomass compared to cultivars 'Santiam' and 'Mt. Hood'. However, no significant differences were found between mulch treatment selections. Results suggest potential for a variety of mulching options to be used by growers and hop as a specialty crop in North Dakota.

IRRIGATED AND NON-IRRIGATED PEANUT (*ARACHIS HYPOGAEA* L.) CULTIVAR RESPONSE TO POSTEMERGENCE PARAQUAT TANK-MIXTURES. K. M. Eason*[1], R. Tubbs[1], T. L. Grey[2], S. Li[3]; [1]University of Georgia, Tifton, GA, [2]University of Geogia, Tifton, GA, [3]Auburn University, Auburn, AL (9)

ABSTRACT

Paraquat is used as a postemergence (POST) herbicide to control broadleaf and grass weed species in peanut in the Southeast. The objective of this study was to determine the effects of POST herbicide tank-mixtures including paraquat on vegetation, yield, and grade for runner type peanut cultivars under irrigated and non-irrigated conditions. Two separate experiments (irrigated and non-irrigated) were conducted in 2016 and 2017 in Ty Ty and Plains Georgia. Georgia-06G, Georgia-14N, TUFRunner™ '511', and FloRun™ '157' cultivars were evaluated. Herbicide tank-mixtures included paraquat, paraquat plus acifluorfen plus bentazon, paraquat plus acifluorfen plus bentazon plus S-metolachlor, and paraquat plus acifluorfen plus bentazon plus acetochlor. Leaf burn, stunting injury, yield, and grade were evaluated. There were no interactions between herbicide and cultivar for all variables. Paraquat alone resulted in significantly greater foliar injury (3 DAT) than the other herbicide treatments for the irrigated (34-16%) and non-irrigated (28-15%) studies. Stunting for paraquat alone was noted at 15 and 35% for irrigated and non-irrigated, respectively. Similarly, in both studies, Georgia-06G and TUFRunner™ '511' yielded 10 to 12% greater than Georgia-14N and FloRun™ '157'. Overall, the herbicide tank-mixtures did not have a negative effect on yield. With no interactions observed, these herbicide treatments can be used in conjunction with the given runner-type peanut cultivars in either irrigated or non-irrigated conditions without concern for excessive injury or decline in yield or grade.

MANAGING PALMER AMARANTH WITH SEQUENTIAL APPLICATIONS OF DICAMBA AND GLUFOSINATE WITH AND WITHOUT ACETOCHLOR. G. K. Flusche Ogden*[1], P. A. Dotray[1], J. D. Everitt[2]; [1]Texas Tech University, Lubbock, TX, [2]Bayer Crop Science, Lubbock, TX (10)

ABSTRACT

Palmer amaranth (*Amaranthus palmeri* S. Wats.) is native to the southwestern region of the US and for decades has been one of the most common weeds in west Texas. In recent years, this weed has been considered one of the most troublesome weeds across the entire southern US. The management of Palmer amaranth has changed since the discovery of glyphosate resistant populations in 2005. Dicamba tolerant cotton systems were introduced in 2017 and provide a new opportunity to manage glyphosate resistant populations. The use of glufosinate (Liberty® 280 SL) plus the postemergence residual herbicide acetochlor (Warrant®) in a dicamba-based system may not only improve the management of glyphosate-resistant Palmer amaranth, but also be effective against new developments of herbicide resistance to group 4 modes of action. A field study was conducted in a non-cropland environment in Lubbock, Texas in 2018 to determine the influence of sequential order when applying dicamba (XtendiMax® with VaporGrip Technology® at 0.56 kg ae ha^{-1}) and glufosinate (0.59 or 0.89 kg ai ha^{-1}) on Palmer amaranth across different growth stages (<10 cm, 10 to 20 cm, >30 cm). Additionally, this study examined the benefit of adding acetochlor (1.27 kg ai ha^{-1}) in tank mixture in one of the sequential postemergence applications. The population of Palmer amaranth at this location averaged over 100 plants per square meter. When evaluated 7 days after initial application, treatments containing glufosinate averaged greater Palmer amaranth control than treatments containing dicamba across all weed sizes. However, when evaluated 21 days after the sequential application, treatments of dicamba followed by (fb) dicamba and dicamba fb glufosinate controlled less than 10 cm Palmer amaranth >90%, which was greater than the control provided by glufosinate fb dicamba and glufosinate fb glufosinate. When evaluated 21 days after the sequential application, glufosinate fb dicamba controlled 10 to 20 cm Palmer amaranth 74%, which was greater than dicamba fb glufosinate. No treatment controlled 30+ cm Palmer amaranth more than 55%. Acetochlor improved weed control when added to several tank mixes, such as glufosinate + acetochlor fb glufosinate (91%) compared to glufosinate fb glufosinate (<90%) for less than 10 cm weeds when evaluated 21 days after the sequential application. This study will be repeated in 2019 in a non-cropland environment as well as in-crop using overhead pivot irrigation.

PALMER AMARANTH (*AMARANTHUS PALMERI*) SURVIVAL AND FECUNDITY AFTER VARIOUS HERBICIDE TREATMENTS AND APPLICATION TIMINGS. E. B. Scruggs*, M. L. Flessner; Virginia Tech, Blacksburg, VA (11)

ABSTRACT

Palmer amaranth (*Amaranthus palmeri* S. Watson) is a troublesome weed for soybean growers due to its aggressive growth and resistance to glyphosate and ALS-inhibiting herbicides. Palmer amaranth (Palmer) control is further limited by PPO-inhibitor resistance, recently confirmed. Two field studies were initiated with the overarching goal of mitigating PPO resistance: (1) following PPO herbicides applied PRE to evaluate POST herbicides for Palmer control and (2) to compare POST herbicidal control across various Palmer heights.

The field studies were conducted in Lunenburg County, Virginia in 2018 and utilized randomized complete block designs with four replications and a nontreated check. All herbicide rates remained the same throughout both studies. Treatments in study one consisted of flumioxazin (89 g ai ha^{-1}), sulfentrazone (280 g ai ha^{-1}), or fomesafen (420 g ai ha^{-1}) applied PRE alone and followed by (fb) either mesotrione (105 g ai ha^{-1}), dicamba (560 g ae ha^{-1}), 2,4-D choline (1060 g ai ha^{-1}), glufosinate (656 g ai ha^{-1}), or fomesafen each tank mixed with glyphosate (1260 g ae ha^{-1}) applied POST. Additionally, glyphosate was applied alone POST. PRE treatments were applied to a weed free area on May 22, 2018. All treatments included adjuvants and utilized nozzles as noted on product labels. POST treatments were applied on July 6, 2018, when weeds were ~13 cm tall. Data collected included visible control assessed on a 0 (no control) to 100% (complete necrosis) scale 45 d after PRE, 28 d after POST (DAP), and weed counts prior to POST applications (45 d after PRE). Treatments in study two included the following alone and in combinations with fomesafen: mesotrione, dicamba, 2,4-D choline, glufosinate, glyphosate, and fomesafen (alone only). Emerged weeds were counted and flagged according to size (5 to 10, 10 to 20, and 20 to 30cm tall) prior to application. POST treatments were applied on June 21, 2018 and visible control was evaluated 26 days after treatment (DAT). Data were subjected to ANOVA and subsequent means separation using Fisher's Protected LSD (α=0.05). The nontreated check was excluded from statistical analysis of visible control data.

In study one, both sulfentrazone and fomesafen resulted in >70% Palmer control 45 d after PRE. There were no differences between sulfentrazone and fomesafen (both <1.2 plants m^{-2}) although flumioxazin resulted in 2 plants m^{-2}. All treatments resulted in better control (>65%) than glyphosate alone (46%), 28 d after POST. Dicamba-containing treatments resulted in the best control (>97%) as compared to mesotrione-containing treatments (65 to 75%) or fomesafen-containing treatments (66 to 70%). All 2,4-D and glufosinate treatments resulted in ≥84% control with the exception of flumioxazin fb glufosinate which resulted in only 66% control. In study two, all treatments resulted in ~70% control of 5 to 10cm Palmer with the exception of mesotrione (19%), 2,4-D (31%), and glyphosate (34%). All treatments resulted in ≥44% control of 10 to 20 cm weeds with the exception of mesotrione (0%) 26 DAT. Mesotrione alone resulted in unacceptable control (<19%) of all weed sizes. The addition of fomesafen to mesotrione increased the control across all sizes (63%, 56%, and 31%; respectively) and glyphosate on 5 to 10 cm Palmer (63%). Control across all treatments decreased as weed size increased. These studies reinforce the importance of targeting small (<10cm) weeds as well as the effectiveness of dicamba, 2,4-D, and glufosinate on escapes from PPO-containing PRE-herbicides. Future research should investigate the efficacy of these treatments on PPO-resistant Palmer amaranth populations and other weed species.

SAFENER MAY ENHANCE TOLERANCE TO SOIL-APPLIED HERBICIDE FOR WINTER WHEAT VARIETIES GROWN IN THE PACIFIC NORTHWEST. D. A. Raiyemo*[1], J. Campbell[2], R. Ma[3], W. J. Price[1], T. Rauch[4], T. Prather[2]; [1]University of Idaho, Moscow, ID, [2]UNIVERSITY OF IDAHO, Moscow, ID, [3], Moscow, ID, [4]UNIVERSITY OF IDAHO/PSES DEPT, Moscow, ID (12)

ABSTRACT

Safener May Enhance Tolerance to Soil-Applied Herbicide for Winter Wheat Varieties Grown in the Pacific Northwest. D. A. Raiyemo*[1], J. M. Campbell[1], R. Ma[2], W. J. Price[1], T. A. Rauch[1], T. S. Prather[1], [1]University of Idaho, Moscow, ID, [2]Bayer CropScience, Chesterfield, MO.

Abstract

The Pacific Northwest of the United States is a productive wheat growing region with significant yield losses from nonindigenous annual grasses. Resistance to Group 1 and 2 herbicides used for annual grass control is a problem to farmers in the region. Safener-induced tolerance of winter wheat to Group 15 herbicides that cause injury to wheat but control these annual grasses could provide additional herbicides to address yield losses. The safener fluxofenim is registered for use only in sorghum, so response variation among wheat varieties was investigated by treating nineteen soft white winter wheat varieties with fluxofenim at 0.5 g ai kg^{-1} seed and then applying *S*-metolachlor at 1418 g ai ha^{-1}, dimethenamid-P at 1005 g ai ha^{-1} or pyroxasulfone at 118 g ai ha^{-1}. Seeds of each variety were planted 2 cm deep in pots containing potting mix within 48 hours of seed treatment and sprayed with herbicides in a compressed-air research sprayer. Herbicide in each pot was incorporated to a depth of 0.6 cm with 83 ml of water via overhead irrigation. Experimental design was a randomized complete block design with four replications and the experiment was repeated. Additionally, aboveground response of six varieties to incremental doses of fluxofenim at 0.2, 0.4, 0.6, 0.8, 1.6 and 3.2 g ai kg^{-1} seed were evaluated to identify any negative effects of fluxofenim on winter wheat. Aboveground biomass was harvested at 21 DAT for all experiments and dried in an oven at 60°C for 72 hours. Data were

subjected to ANOVA using GLIMMIX procedure and means of biomass separated with Fisher's LSD at 95% confidence level. Nonlinear regression model was fitted to the dose-response data with NLMIXED procedure in SAS. Results showed that increased tolerance in winter wheat to *S*-metolachlor, dimethenamid-P and pyroxasulfone were variety-dependent. Four varieties had significantly high aboveground biomass with herbicide + safener treatments for both *S*-metolachlor and dimethenamid-P herbicides compared to their respective herbicide treatment only. Fluxofenim improved the biomass of LWW 15-72458 with pyroxasulfone treatment. Interestingly, varieties UI Castle CL+, UI Palouse CL+ and 09-15702A were tolerant to the three herbicide treatments regardless of the safener fluxofenim. Untreated control for all varieties were statistically indistinguishable from safener only treatment. Six varieties were then selected for further study based on positive, mixed and no response to safener across both *S*-metolachlor and dimethenamid-P herbicide treatments as well as their popularity in Idaho. Fluxofenim dose required to reduce biomass of selected wheat varieties by 50% (ED_{50}) could not be estimated from the data, therefore dose resulting in 10% (ED_{10}) biomass reduction were estimated. ED_{10} values ranged between 1.5X for UI Castle CL+ to 5.25X for UI Palouse CL+ of the labelled rate for sorghum (0.4 g ai kg^{-1} seed). These greenhouse experiments were first in a series of experiments. Further studies will investigate the effects of herbicide and safener to six varieties in the field, and differential expression of detoxification genes conferring herbicide tolerance to safener-treated varieties. raiy0068@vandals.uidaho.edu

COMPARISON OF HERBICIDE PROGRAMS IN CONVENTIONAL, GLUFOSINATE-RESISTANT, AND GLYPHOSATE/DICAMBA-RESISTANT SOYBEAN ACROSS NEBRASKA. A. Striegel*[1], S. Z. Knezevic[2], N. C. Lawrence[3], G. L. Hein[2], G. Kruger[4], C. Proctor[2], A. J. Jhala[2]; [1]University of Nebraska Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]University of Nebraska-Lincoln, Pullman, WA, [4]University of Nebraska-Lincoln, North Platte, NE (13)

ABSTRACT

Field experiments were conducted at three irrigated (south-central, west-central, western) and two rain-fed locations (northeastern and eastern Nebraska) to evaluate PRE fb POST herbicide programs for weed control and yield reductions in conventional, glufosinate and glyphosate/dicamba-resistant soybean varieties. Experiments were conducted in a split-plot design with five PRE herbicide programs, nontreated control, and weed free check as the main plot and four soybean varieties and POST herbicide program as the subplot. Reductions to weed biomass, density and yield were different among locations and analyzed separately, with the exception of weed density reduction 28 d after POST which was combined across locations. All PRE herbicide programs provided 95-99% reduction in weed biomass at northeastern and western Nebraska research locations. Most PRE herbicide programs reduced weed density to 72-82%, 41-61%, and 98-100% at 28 d after PRE at south-central, northeastern, and western Nebraska research sites, respectively. POST herbicide programs reduced weed biomass by 99% for dicamba plus glyphosate, 95-99% for glyphosate and 96-99% for glufosinate across all locations. However, lactofen plus clethodim plus acetochlor provided 69, 99, and 99% biomass reduction at 28 d after POST at south-central, northeastern, and western Nebraska, respectively. Weed density was reduced 96% with dicamba plus glyphosate, 92% for glyphosate, 91% for glufosinate, and 83% for lactofen plus clethodim plus acetochlor at 28 d after POST. PRE herbicide program yield reductions compared to weed free check were similar for all PRE herbicide programs at the northeastern and western Nebraska locations, with yield reductions of 12% for flumioxazin/pyroxasulfone plus metribuzin, 21% for chlorimuron/flumioxazin/thifensulfuron, 9% for flumioxazin/pyroxasulfone plus metribuzin, 14% for chlorimuron/flumioxazin/metribuzin and 22% for imazethapyr/pyroxasulfone/saflufenacil at south-central Nebraska. POST herbicide yield reductions were 0% for dicamba plus glyphosate, 8, 4 and 6% for glyphosate, 15, 3 and 0% for glufosinate, and 33, 8 and 0% for lactofen plus clethodim plus acetochlor at 28 d after POST across south-central, northeastern, and western Nebraska, respectively.

COVER CROPS SUPPRESS WEEDS IN YOUNG COFFEE PLANTATIONS. L. S. Resende*, A. O. Alecrim, K. G. Figueiredo, F. C. Medeiros, R. J. Guimarães; Federal University of Lavras, Lavras, Brazil (14)

ABSTRACT

With an increasing number of herbicide-resistant weed species, it has become apparent that alternative methods of weed suppression should be examined. The objective of this study was evaluate weed incidence in young coffee plantations intercalated with cover crops cultivated in strips with different distances to the coffee plants. The experiment was conducted in the Departament of Agriculture located in Lavras, MG, Brazil. Treatments were arranged in a factorial scheme with three replications. Factor A was composed by four distances (0,25; 0,50; 0,75; 1 m). Factor B was composed by four cover crops, namely: forage peanut (*Arachis pintoi*), signal grass (*Urochloa decumbens),* jack bean (*Canavalia ensiforms L.),* velvet bean (*Mucuna deeringiana* var. anã) and a control treatment with no cover crop. In each experimental unit, weed species were identified and quantified according to the inventory square method (0,25m^2) with four repetitions. Twenty three species of weed plants were identified, distributed in eleven families and the family *Poaceae* showed the largest number of species. The species most common founded were: jamaican crabgrass (*Digitaria horizontalis*), purslane (*Portulaca oleracea*), brazilian pusley (*Richardia brasiliensis*), goosegrass (*Eleusine indica*), wormwood (*Parthenium hysterophorus*), spiderwort (*Commelina benghalensis*). Jack bean and velvet bean were the most competitive cover crops based on total weed populations ($P<0.05$). The treatment without cover crops showed the highest number of weed plants. This research indicates that cover crops could be used in integrated weed management programs to provide weed control in coffee crops and reduce the use of herbicides.

EFFECT OF CARRIER VOLUME AND NOZZLE SELECTION ON GLUFOSINATE AND 2,4-D EFFICACY. S. Davis*[1], D. Dodds[2], T. W. Eubank[3], L. X. Franca[2], J. P. McNeal[4], B. Norris[1], J. J. Williams[1]; [1]Mississippi State University, Starkville, MS, [2]Mississippi State University, Mississippi State, MS, [3]Mississippi State University, Stoneville, MS, [4]Mississippi State University, Mississippi State, Mississippi, MS (15)

ABSTRACT

EFFECT OF HERBIVORY AND SOIL FERTILITY ON CHINESE TALLOW IN LOUISIANA: INSIGHTS FOR MANAGEMENT. O. C. Omoyele*; Veronica Manrique, Rodrigo Diaz, Baton Rouge, LA (16)

ABSTRACT

EFFECT OF HERBIVORY AND SOIL FERTILITY ON CHINESE TALLOW IN LOUISIANA: INSIGHTS FOR MANAGEMENT

O.C. Omoyele, Veronica Manrique, Rodrigo Diaz

ABSTRACT

Chinese tallow tree (*Sapium sebiferum (L.) Roxb. Syn. Triadica sebifera (L.)* Small) is a subtropical deciduous tree native to Eastern Asia. Chinese tallow is a serious invader throughout the southeastern United States. It's an aggressive woody invader of marshes, wetland, coastal, and disturbed habitats where it reduces native species diversity and richness, and it also alters ecosystem structure and function in natural areas. Management of Chinese tallow is costly and mostly ineffective. A biological

control agent, the flea beetle *Bikasha collaris* (Coleoptera: Chrysomelidae), is currently being considered against this invasive tree. In order to estimate the effectiveness of this agent, this study examined the effect of plant fertility and herbivory on Chinese tallow growth in Louisiana. A plot of Chinese tallow trees was established at Southern University, Baton Rouge, LA in June 2018. A total of 64 saplings (1-year-old) were planted in 8 rows with 8 plants per row. A factorial experiment was established with fertility (slow release fertilizer, Osmocote NPK 15-9-12) and herbivory as factors. For the herbivory treatment, we simulated feeding damage by *B. collaris* by doing 20% leaf removal using clippers and root damage using the root assassin shovel (10% estimation). Several plant parameters (basal stem diameter, plant height, etc.) were recorded bimonthly starting in June 2018 (5 replications per fertility x herbivory treatment). Results of this study will be discussed in the context of effective management and potential outcomes of future biological control.

ELEVATED CO_2 EFFECT ON THE GERMINATION INDEX (GI) AND EMERGENCE INDEX (EI) OF RED RICE AND JOHNSONGRASS. J. C. Argenta*, S. Finlayson, T. Gentry, M. V. Bagavathiannan, K. Carson; Texas A&M University, College Station, TX (17)

ABSTRACT

The concentration of carbon dioxide in the atmosphere is expected to increase in the near future. However, the exact impact of its rise is still not clear when considering the whole soil-plant-atmosphere continuum. Previous studies demonstrated elevated [CO_2] can impact seed germination. Thus, the objective of this study was to evaluate the effect of elevated atmospheric [CO_2] on the germination index (GI) and emergence index (EI) of red rice and Johnsongrass. The experiment was conducted in growth chamber under [CO_2] of 400 ppm and 700 ppm, and both GI and EI were calculated using Maguire's formula. Statistical analyses were conducted using JMP® Pro v. 14.20, and consisted of analysis of variance (ANOVA) and significant differences by LSD – Fisher's test. Results show that elevated CO_2 did not affect GI and EI for red rice. However, CO_2 had negative impact on the GI and EI for Johnsongrass, decreasing both germination and emergence index. Since Johnsongrass has a hard seed coat and a different photosynthetic pathway than red rice, seed morphology and photosynthetic carbon cycle may play a larger role in determining this complex dynamic, but each species must be evaluated individually. Additionally, an increase in the atmospheric [CO_2] can possibly increase [CO_2] in the soil, and as a consequence, influence soil pH and affect microbial activity. More research is needed to better understand the influence of [CO_2] on the mechanisms in this complex continuum.

HARVEST WEED SEED CONTROL FOR JOHNSONGRASS IN GRAIN SORGHUM: A FEASIBILITY ANALYSIS. B. L. Young*[1], D. Sarangi[1], N. E. Korres[2], L. M. Lazaro[3], M. J. Walsh[4], J. K. Norsworthy[2], M. V. Bagavathiannan[1]; [1]Texas A&M University, College Station, TX, [2]University of Arkansas, Fayetteville, AR, [3]Louisiana State University AgCenter, Baton Rouge, LA, [4]University of Sydney, Narrabri, Australia (18)

ABSTRACT

Concurrent maturity of crops and the weeds can result in the harvesting of weed seeds into the commercial harvester and subsequent redistribution of the seeds to the soil surface. Therefore, harvest weed seed control was proposed to be an effective means to minimize this problem. Experiments were conducted in 2016 and 2017, at College Station, TX to estimate the seed shattering potential of johnsongrass under field conditions. Four plastic trays (25.4 cm × 25.4 cm) were placed around each johnsongrass plant to capture all the shattered seeds till the sorghum harvest and the number of seeds collected in each tray were counted on a weekly basis and discarded. Results of the seed shattering data showed that johnsongrass at the time of harvest retained seeds at levels with potential for HWSC methods. Sorghum fields infested with johnsongrass in southern Texas were surveyed in 2017 and 2018 and the johnsongrass seedheads with mature seed, at above and below the commercial harvester cutting height were sampled to determine the number of seeds could be destroyed using a harvest weed seed destructor. Results have shown potential in the tactics for harvest weed seed control with around 80% of the seed produced to be obtained by HWSC methods. Higher seed retention above the cutting height at crop maturity, as revealed from this study, indicates the potential for harvest weed seed control tactics to reduce the seed bank addition and spread of this species by seeds.

INFLUENCE OF DICAMBA EXPOSURE ON GLUFOSINATE RESISTANT SOYBEAN CANOPY CLOSURE. Z. K. Perry*[1], M. D. Kramer[2], T. R. Legleiter[3]; [1]University of Kentucky, Paducah, KY, [2]University of Kentucky, Lynn, IN, [3]University of Kentucky, Princeton, KY (19)

ABSTRACT

Dicamba-resistant soybean along with lower volatility dicamba formulations have been introduced in an attempt to control herbicide resistant weeds such as *Amaranthus palmeri*. This introduction has increased the amount of dicamba being applied later in the growing season increasing the prevalence of dicamba off-target movement. Off-target movement of dicamba caused over 3 million acres of soybean damage nationwide in 2017 and 2018. The objective of this experiment was to evaluate the influence of timing and dosage of dicamba exposure on soybean canopy development. In the following experiment, dicamba damage was mimicked by applying low rates of dicamba on soybeans at rates of 0.5 g ae ha^{-1}, 1 g ae ha^{-1} and 5 g ae ha^{-1} dicamba. Trial design was a randomized complete block design with four replications. The site was maintained and remained weed free, to prevent any type of vegetation from interfering with the canopy images. Canopy development was assessed using Canopeo photos to determine a percentage of canopy closure compared to the untreated check. Photos were taken 28 days after application to determine the effects of the dicamba exposure. The influence of exposure date was greater in canopy development delay than the influence of rate. Reductions in canopy development as compared to a non-exposed treatment was greater in exposures on July 3rd and July 11th than on June 5th. The greatest reduction on canopy development as compared the untreated occurred when exposure occurred on July 3rd at a rate of 5 g ae ha^{-1}.

MANAGING HORSEWEED IN SOYBEAN WITH COVER CROPS AND HERBICIDES. J. A. Schramski*, C. Sprague, K. Renner; Michigan State University, East Lansing, MI (20)

ABSTRACT

Prolonged emergence of herbicide-resistant horseweed has deemed reliance on chemical control ineffective for Michigan soybean growers; alternative management strategies need to be considered. Fall-planted cereal cover crops could aid herbicide programs in suppressing fall and early-spring emerging horseweed, as well as provide additional residue cover to improve season-long control. In 2018, an experiment was conducted in Mount Pleasant, Michigan to evaluate the effects of fall-planted cereal cover crops in combination with different herbicide programs to manage herbicide-resistant horseweed.The experiment was set up as a split-plot design with cover crop treatments of cereal rye and winter wheat drilled at two different seeding rates (67 and 135 kg ha^{-1}) in fall 2017 and a no cover control. Within each main plot three herbicide burndown subplots included: 1) glyphosate only burndown (control), 2) glyphosate + 2,4-D ester burndown (no residual), and 3) glyphosate + 2,4-D ester + flumioxazin + metribuzin burndown (residual). Burndown herbicide treatments were applied one week prior to planting dicamba-resistant soybean. Control and no residual subplots received a postemergence (POST) application of dicamba + glyphosate six weeks after treatment (WAT); dicamba was not applied to residual subplots because horseweed control was greater than 97% at this time. The majority of horseweed at this research location emerged in the spring and continued to emerge weekly through August. Peak emergence occurred in two periods, prior to burndown in early May and after soybean planting in mid-June (4 WAT). The high cover crop seeding rate resulted in 14 to 34% more cover biomass than the low seeding rate; however, seeding rate had no impact on horseweed suppression during the season. Prior to burndown, fall-planted cereal cover crops reduced early-spring emerging horseweed density and biomass 53 and 54% compared with no cover, respectively. Cereal rye and winter wheat did not affect densities of later emerging horseweed following burndown. However, the additional cover from cereal rye and winter wheat reduced horseweed biomass26 to 38% compared with no cover at the time of the POST application. Combined over covers, the residual herbicide treatments provided 97% horseweed control at this time, while no residual and the control treatments only provided 42 and 8%, respectively. Following a dicamba application, fall-planted cover crops had no effect on horseweed control. Horseweed rosettes were equally present in all treatments at soybean harvest; residual treatments had some flowered horseweed plants which likely emerged prior to POST applications of dicamba in the control and no residual treatments. Combined over covers, soybean yield in the residual and no residual treatments were 60 and 24% better than the control, respectively, emphasizing the importance of early-season horseweed control. Soybean yield was not affected by cover crop.

PHENOTYPIC CHARACTERISTICS OF F1 HYBRID PROGENIES OF *SORGHUM BICOLOR* X *S. HALEPENSE*. C. Sias*[1], S. Ohadi[2], G. Hodnett[1], W. Rooney[1], M. V. Bagavathiannan[1]; [1]Texas A&M University, College Station, TX, [2]University of California, Davis, Davis, CA (21)

ABSTRACT

Gene flow between cultivated species and their wild relatives can pose severe threats to the efficiency of weed management programs and the sustainability of the tools that are utilized in them. In Sorghum production systems of Texas, potential for gene flow between Sorghum bicolor and its weedy relative S. halepense is an emerging concern, given the anticipated commercialization of the acetolactate-inhibitor tolerant grain sorghum. Yet, little is known on the fate of gene flow, especially the phenotypic characteristics of the F1 hybrid progenies. Greenhouse and field experiments were conducted at Texas A&M University, College Station to characterize the F1 progenies produced between the two species when sorghum was used as the female parent. Four different ploidy types (3x, 4x, 5x, 6x) obtained during controlled hybridizations were characterized for 14 different morphological traits, including fertility status, rhizome production and seed characteristics. Preliminary results showed that there were significant differences in phenotypic characteristics among different F1 progeny types. In particular, rhizome production varied across the progenies and appeared to be influenced by resource availability. Findings will be useful for risk assessment of gene flow between sorghum and johnsongrass.

PLANT DEMOGRAPHY OF CHINESE TALLOW IN LOUISIANA: BASELINE INFORMATION NEEDED FOR SUSTAINABLE MANAGEMENT. D. Sevor*[1], V. Manrique[1], R. R. Diaz[2]; [1]Southern University and A&M College, Baton Rouge, Baton Rouge, LA, [2]Louisiana State University, Baton Rouge, LA (22)

ABSTRACT

Chinese tallow, *Triadica sebifera* (L.) Small (Euphorbiaceae) is a highly invasive non-native tree species in the southeastern USA. The invasion by this tree often results in a closed canopy of Chinese tallow with few other species present thereby changing species composition and community structure in invaded ecosystems. Effective management of this invasive species is challenging as current control tactics have proven to be ineffective and costly. The flea beetle *Bikasha collaris* (Bali) (Coleoptera: Chrysomelidae) is currently being considered as a biological control agent of Chinese tallow in the USA. A petition for release of this insect was submitted to APHIS-PPQ in April 2016, and is waiting for final approval. Pre-release studies are important to assess and characterize weed populations in invaded areas before the agent is introduced. Therefore, the objectives of this study were to: 1) examine impact of local natural enemies attacking Chinese tallow in Louisiana and, 2) determine plant demographic of Chinese tallow populations in central and south Louisiana. A plot of Chinese tallow trees was established at LSU Burden Botanical Gardens, Baton Rouge, LA in June 2018. A total of 80 saplings (1-year-old) were planted in 8 rows with 10 plants per row. An insecticide treatment (Acephate, Bonide) was used in half of the plants to prevent insect damage, while the other half was left as controls (no insecticide). Several plant parameters (basal stem diameter, plant height, etc.) and insect damage (percent leaves damage) were recorded bimonthly starting in June 2018 (experiment will end in Fall 2019). For the demography study, two sites invaded with Chinese tallow were selected in New Orleans and Pineville, Louisiana. Chinese tallow trees of different age classes were tagged in an area of 20 x 20 m in each field site in October 2018. Several demographic parameters such as stem diameter, plant reproductive status, survival, seed rain, will be recorded few times per year in 2018 and 2019. Significance of the results will be discussed in the context of pre-release assessment of Chinese tallow populations in Louisiana for future comparisons before biological control is initiated.

RESPONSE OF INSECT PEST AND BENEFICIAL SPECIES TO THE TIMING AND SEVERITY OF DICAMBA INJURY IN SOYBEAN. W. A. Tubbs*, K. Rice, M. Bish, K. Bradley; University of Missouri, Columbia, MO (23)

ABSTRACT

Response of Insect Pest and Beneficial Species to the Timing and Severity of Dicamba Injury in Soybean.

William Tubbs*, Kevin Rice, Mandy Bish, and Kevin Bradley; University of Missouri, Columbia, MO

Off-target movement of dicamba has been one of the most significant issues to affect non-dicamba-tolerant (DT) soybean production during 2017 and 2018. Although a variety of research has been conducted to determine the effects of off-target dicamba movement on soybean yield, few studies have been conducted to understand the effects that dicamba injury has on insect infestations in non-DT soybean. Previous research has shown drift-level doses of dicamba in alfalfa leads to decreased visitation from pollinator species. A field experiment was conducted at four locations in Missouri to determine if dicamba injury to non-DT soybean has any effect on the prevalence and severity of insect pest and beneficial species throughout the growing season. At each location, all herbicide treatments were applied to non-DT soybean at either the V3 or R1 stages of growth. The treatments evaluated included dicamba at rates corresponding to $1/10^{th}$, $1/100^{th}$, $1/1{,}000^{th}$, and $1/10{,}000^{th}$ of the labeled use rate (560 g

ae/ha) and lactofen at 175 g ae/ha. A non-treated control was also included for comparison. The experiment was conducted in a randomized complete block design. Individual plots were 6 by 6 m and replicated six times. Insects were collected by sweep net sampling beginning the day of application and at seven day intervals following application up to 77 days after treatment. Upon collection, all insects were frozen and stored for subsequent identification and analysis. Data were subjected to analysis using the PROC GLIMMIX procedure in SAS and means were separated using Fisher's Protected LSD ($P \leq 0.05$). Results from all locations indicate that insect pest and beneficial species abundance was lowest in non-DT soybean that received an application of dicamba at $1/10^{th}$ the labeled rate at either the V3 or R1 application timing. However, insect pest and beneficial species density was much higher in non-DT soybean that received an R1 application of lactofen or dicamba at rates lower than $1/10^{th}$ the labeled rate. Results indicate that dicamba injury to soybean does not result in a higher incidence of insect pest or beneficial species in soybean compared to the non-treated control.

TANK-CONTAMINATION OF DICAMBA OR 2,4-D INFLUENCES DRY EDIBLE BEAN PRODUCTION. S. R. Bales*[1], C. Sprague[2]; [1]Michigan State University, east lansing, MI, [2]Michigan State University, East Lansing, MI (24)

ABSTRACT

The increasing occurrence of herbicide-resistant weeds coupled with registrations of dicamba- and 2,4-D-resistant soybean will increase the amount of plant growth regulator herbicides (PGR) used in Michigan. Off-target movement to sensitive crops such as dry bean will be of greater concern with increased use. In 2017 and 2018, field experiments were conducted at two locations in Michigan to determine how tank-contamination of dicamba and 2,4-D choline may influence dry bean production. The objectives were to understand how multiple factors may influence dry bean response, including: dry bean class, application timing and the presence of labeled dry bean herbicides (LDBH) in the spray solution. In the first experiment, three rates of each PGR herbicide were applied at V2 and V8 to black and navy beans. Rates included: 0.1, 1 and 10% of the field use rate for dicamba and 2,4-D choline, at rates of 0.56 and 1.1 kg ae ha^{-1}, respectively. The second experiment tested the potential interactions between PGR herbicides and LDBH, treatments included two common LDBH programs: 1) imazamox (35 g ha^{-1}) + bentazon (560 g ha^{-1}) + crop oil concentrate + ammonium sulfate, and 2) fomesafen (280 g ha^{-1}) + crop oil concentrate. The LBDH were contaminated with PGR herbicide (1%), and PGR (1%) herbicide + glyphosate (1% = 8.41 g ae ha^{-1}). All rates of dicamba and 2,4-D choline caused injury to dry edible beans, however yield reductions were not always observed even with high levels of plant injury. Dicamba at the 10% rate caused >38% injury 14 d after treatment (DAT), reduced row closure by 32% (54 d after planting (DAP)), and delayed maturity by 4 to 18 d; resulting in as much as a 26% reduction in yield. Dry beans were less sensitive to 2,4-D. The 10% rate of 2,4-D caused >20% injury 14 DAT and delayed maturity by 2 to 10 d, however, canopy closure and yield were not affected. Timing of PGR exposure and dry bean class often did not affect dry bean response. The interaction between PGR herbicides and the LDBH was synergistic for dicamba, and additive for 2,4-D when analyzing dry bean injury 21 DAT. Dry bean yield and weight per 100 seeds was reduced from dicamba plus LBDH at V8 dry beans. While dry bean yield and quality is not always directly impacted by PGR herbicides, long delays in maturity from PGR injury can have negative impacts on yield and quality due to harvestability issues. These delays would cause difficulties in the timing of legal harvest-aid applications. If PGR residues were detected in exposed beans the crop could be condemned as there is not an established maximum residue limit for either PGR herbicide on dry beans. This work further stresses the need for caution when using PGR herbicides near sensitive crops.

BERMUDAGRASS TOLERANCE OF INDAZIFLAM PREEMERGENCE APPLICATIONS. N. L. Hurdle*[1], T. L. Grey[2], P. McCullough[3]; [1]University of Georgia, Tifton, GA, [2]University of Geogia, Tifton, GA, [3]University of Georgia, Griffin, GA (25)

ABSTRACT

Bermudagrass is a major forage species throughout Georgia and the southeast. An essential part of achieving high yielding-top quality forages is proper weed control. Indaziflam is a residual herbicide that controls many broadleaf and grass species by inhibiting cellulose biosynthesis. Research was conducted in Tift and Coulquitt Counties in Georgia to determine optimal PRE rates at which indaziflam may be applied without causing bermudagrass injury. Treatments applied at spring green up of established Alicia bermudagrass included indaziflam at 37, 73, 147, or 220 g ai ha^{-1} PRE, pendimethalin at 4480 g ha^{-1} PRE, a split application of indaziflam at 37 g ha^{-1} PRE followed by the same treatment POST after the first cutting, and a nontreated control (7 total). Forages were machine harvested at three times each year for each location beginning at least 47 days after treatment (DAT) with final cuttings up to 168 DAT.

For all treatments, fresh and dry weight yields at each harvest and totals for the season did not differ. Indaziflam at 147 or 220 g ha^{-1} caused 15 and 21% stunting at 44 DAT, respectively, but this was transient and not observed at the 2^{nd} harvest. Indaziflam has the potential to control troublesome weeds in bermudagrass forage and hay production, with minor to no risk of stunting or yield loss at the recommended application rates.

HERBICIDES LEACHING POTENTIAL IN ASSOCIATION WITH HYDRORETENT POLYMER. K. G. Figueiredo*, A. T. Reis, C. F. Chagas, A. O. Paiva, L. S. Resende, G. B. Voltolini, F. C. Medeiros; Federal University of Lavras, Lavras, Brazil (26)

ABSTRACT

Herbicides are widely used in agriculture, however some of these products have high capacity to leach in the soil. In this context, the aim of this study was to evaluate the leaching potencial of the herbicides atrazine and diuron in association with different doses of the hydroretent polymer (HB10®) along with the simulation of different precipitations. The experiment was conducted at the Federal University of Lavras (UFLA). The experimental design was completely randomized with four replicates, arranged in a 4x4 factorial scheme. The factors of the design were four doses of the hydroretent polymer (0, 0.025 g, 0.05 g and 0.1 grams in 1 Liter) and four precipitation rates (0, 20, 40 and 80 mm). PVC pipes with 10 cm in diameter and 50 cm in length filled with Red Latosol were used. The pipes were submitted to capillary irrigation and put to rest for 48 hours, until they reached field capacity. The herbicides atrazine (2 kg a.i/ha) and diuron (3.2 kg a.i/ha) were applied to the top of the PVC tubes using a CO_2 pressurized backpack sprayer set at 45 kgf/cm² for application of 300 L/ha. After application of the herbicides, the rain precipitation was simulated, and the tubes were cut longitudinally and separated to sow the bioindicator species (*Cucumis sativus*). The symptoms were assessed using the EWRC (1964) scale 21 days after sowing. No statistical differences were observed when 0 g of the polymer was used. The association of 0.0025 g of polymer with the 40 mm of precipitation resulted in leaching of the herbicides to the depth of 40 cm. With the use of 0.05 g of the polymer, the herbicide atrazine was retained at the depth of 35 cm with the simulation of 40 mm of rain. The herbicide diuron was retained at the depth of 30 cm with the simulation of 80 mm of rain. All the simulations of precipitation were efficient for both herbicides to stay retained in the depth of 25 cm, while maintaining the same efficiency, when the polymer dose of 0.1 g/L was applied. Thus, the rate of leaching for atrazine and diuron can be reduced in association with the hydroretent polymer at the dose of 0.1 g/L.

OFF-TARGET MOVEMENT RISK ASSOCIATED WITH FLYING STRATEGIES, NOZZLE TYPE, AND WIND VARIABILITY FOR AN UNMANNED AERIAL SPRAYER. J. E. Hunter*, R. E. Austin, R. Richardson, T. Gannon, J. Neal, R. Leon; North Carolina State University, Raleigh, NC (27)

ABSTRACT

In recent years, unmanned aerial vehicle (UAV) technology has expanded to include UAV sprayers capable of dispersing liquid pesticides. Created with the intent of conducting small scale broadcast applications, UAV sprayers have value in site-specific weed management practices. Very little has been determined about the spray coverage characterized by UAV-based pesticide applications. The present study was conducted to determine the accuracy and uniformity of UAV-sprayers and determine the off-target movement effects crosswinds may have on applications. Spray patterns produced by different droplet sized nozzles were evaluated at four different flying speeds, and under varying crosswind conditions. The results indicated that spray coverage decreased as flight speeds increased, while nozzles producing smaller sized droplets were more likely to drift off target. The speed of the crosswind and its generated turbulence highly influenced application coverage, consistency, and off-target movement. The study results indicated both nozzle selection and flight speed were crucial parameters for UAV pesticide applications, while the potential for off-target movement may depend on the particular characteristics of the crosswind.

RAINFALL TIMING EFFECTS ON PREEMERGENCE HERBICIDE EFFICACY IN SOYBEAN. P. H. Urach Ferreira[1], L. H. Merritt*[2], D. B. Reynolds[1], J. T. Irby[1], G. Kruger[3], J. Ferguson[1]; [1]Mississippi State University, Mississippi State, MS, [2]Mississippi State University, MS State, MS, [3]University of Nebraska-Lincoln, North Platte, NE (28)

ABSTRACT

Pre-emergence (PRE) herbicide weed control success is affected by environmental factors, namely rainfall. Two greenhouse experiments were conducted in 2017 and in 2018, studying the effect of simulated rain at two, four and eight days after herbicide application (DAA). Applications were made over weed species treated with five PRE herbicides and sprayed with three different nozzle types. The five herbicide treatments used were clomazone at 1122 g ha^{-1}, imazethapyr at 70 g ha^{-1}, metribuzon at 701 g ha^{-1}, pendimethalin at 1062 g ha^{-1}, and pyroxasulfone at 178 g ha^{-1}. Nozzles tested were: XR 11002, ULD 12002, and TTI 11002. Water was applied using the rainfall simulator in a research track sprayer at 10 mm and three timings were tested: 2 DAA, 4 DAA, and 8 DAA. Herbicide type was significant for grass and broadleaf control. For grass control, all herbicides produced significantly lower dry weights compared to the untreated check across rainfall timings. Clomazone had the lowest dry weight but was not significantly different than the other herbicides. For broadleaf control, pendimethalin had the least effect on dry weight biomass at the 2 and 4 DAA rainfall timings. Rainfall timing had a significant effect on broadleaf weed control, but not on grass control. The 8 DAA rainfall timing resulted in the lowest dry weights compared to the 2 DAA rainfall timing. Nozzle type had no significant effect on grass and broadleaf dry weights which showed that droplet size was not a factor in herbicide efficacy across rainfall timings.

REPEAT APPLICATIONS OF POSTEMERGENCE TURFGRASS HERBICIDES FOR SEASON-LONG YELLOW NUTSEDGE (*CYPERUS ESCULENTUS*) CONTROL. N. S. Minaev*[1], J. D. McCurdy[2], M. P. Richard[1], Z. D. Small[3]; [1]Mississippi State University, Starkville, MS, [2]Mississippi State University, Mississippi State University, MS, [3]Mississippi State University, Mississippi State, MS (29)

ABSTRACT

Repeat Applications of Postemergence Turfgrass Herbicides for Season-long Yellow Nutsedge (*Cyperus esculentus*) control

Yellow nutsedge (*Cyperus esculentus*) is a troublesome perennial weed in maintained turfgrass. Research was conducted at Mississippi State University to evaluate common postemergence nutsedge control options. This study was conducted twice in time (5 July, 2017 and 12 July, 2018).

The study was conducted as a randomized complete block (4) design at Mississippi State University in a fallow area with approximately 90% yellow nutsedge and 5% bermudagrass cover. The site was mown weekly (5 cm mowing height). Experimental units were 2m × 3m. Treatments were applied in a water carrier volume of 374 L ha^{-1} via a CO_2 pressurized back pack sprayer and included: a non-treated check, MSMA (2.27 kg ai ha^{-1}), bentazon (1.12 kg ha^{-1}), halosulfuron-methyl (0.07 kg ha^{-1}) + non-ionic surfactant (NIS), trifloxysulfuron-sodium (0.028 kg ha^{-1}) + NIS, imazaquin (0.56 kg ha^{-1}) + NIS, sulfosulfuron (0.066 kg ha^{-1}) + NIS, imazosulfuron (0.74 kg ha^{-1}) + NIS, flazasulfuron (0.16 kg ha^{-1}) + NIS, thiencarbazone-methyl (0.022 kg ha^{-1}) + foramsulfuron (0.045 kg ha^{-1}) + halosulfuron-methyl (0.069 kg ha^{-1}) + NIS + ammonium sulfate (1.68 kg ha^{-1}), pyrimisulfan (0.053 kg ha^{-1}) + penoxsulam (0.053 kg ha^{-1}), sulfentrazone (0.21 kg ha^{-1}), sulfentrazone (0.21 kg ha^{-1}) + imazethapyr (0.042 kg ha^{-1}), carfentrazone-ethyl (0.023 kg ha^{-1}) + sulfentrazone (0.21 kg ha^{-1}), sulfentrazone (0.21 kg ha^{-1}) + quinclorac (0.63 kg ha^{-1}), sulfentrazone (0.21 kg ha^{-1}) + metsulfuron-methyl (0.021 kg ha^{-1}), sulfentrazone (0.21 kg ha^{-1}) + prodiamine (0.42 kg ha^{-1}), s-metolachlor (2.12 kg ha^{-1}) + NIS, dimethenamid (1.12 kg ha^{-1}). When included, NIS was applied at 0.25% v v^{-1}. All products were reapplied 4 weeks after initial application. Control was assessed visually 4 and 10 weeks after initial treatment (WAIT). Data were subject to analysis of variance ($\alpha = 0.05$). Means were separated using Student Newman Keuls method within SAS proc GLIMMIX.

For brevity, greater than 80% control at the 10 WAIT evaluation was deemed acceptable. When assessed 10 WAIT in 2017, halosulfuron, imazaquin, pyrimisulfan + penoxsulam, bentazone, sulfentrazone + imazethapyr, MSMA and carfentrazone + sulfentrazone controlled yellow nutsedge greater than 80%. Only flazasulfuron (46%), sulfentrazone + metsulfuron-methyl (45%), and thiencarbazone-methyl + foramsulfuron + halosulfuron-methyl (15%) failed to provide long term control of yellow nutsedge. Much of this lack of control is attributed to regrowth of yellow nutsedge after the second application.

In 2018 sulfosulfuron, trifloxysulfuron, imazaquin, halosulfuron, thiencarbazone-methyl + foramsulfuron + halosulfuron-methyl, imazosulfuron, flazasulfuron, and pyrimisulfan + penoxsulam controlled yellow nutsedge greater than 80%. Only metolachlor, sulfentrazone + prodiamine, and dimethenamid failed to provide long term control of yellow nutsedge.

When data are forced pooled over the two years of this study, halosulfuron, imazaquin, pyrimisulfan + penoxsulam, trifloxysulfuron, and sulfosulfuron treatments provided acceptable yellow nutsedge control (≥ 80%). Research was conducted in a fallow area with very little turf competition and infrequent mowing. In a competitive turf sward, yellow nutsedge control may be prolonged beyond what was observed in this study. Future research should evaluate effects of turf competition, as well as herbicide efficacy on a broader range of weed species.

RESPONSE OF SEASHORE PASPALUM (*PASPALUM VAGINATUM* SW.) AND HYBRID BERMUDAGRASS (*CYNODON DACTYLON* X *C. TRANSVAALENSIS* L. PERS.) TO TOPRAMEZONE AND TRICLOPYR MIXTURES. C. G. Goncalves*[1], A. M. Brown[2], J. R. Jim Harris[2], J. S. McElroy[2]; [1]Auburn University, auburn, AL, [2]Auburn University, Auburn, AL (30)

ABSTRACT

Methods for managing bermudagrass (*Cynodon dactylon* (L.) Pers. x *C. transvaalensis* Burtt Davy) invasion of seashore paspalum (*Paspalum vaginatum* Sw.) are limited. In 2016 and 2017, a field study at the Auburn University (Sports Surface Field Laboratory) evaluated Tifway bermudagrass control and seashore paspalum injury following sequential applications of topramezone alone and in combination with triclopyr. Treatments included two sequential sprayings of topramezone (15.6 a.i. g ha^{-1}) and five rates of topramezone + triclopyr (15.6 + 43.2, 15.6 + 86.3, 15.6 + 172.6, 15.6 + 345.2, and 15.6 + 690.4 g a.i. ha^{-1}). Topramezone in combination with triclopyr improves bermudagrass control and reduces seashore paspalum injury compared to topramezone alone. Topramezone + triclopyr at 14.6 + 690.4 g a.i. ha^{-1} applied sequentially controlled bermudagrass > 90% at 14 days after second application, however control decreased over time. Unfortunately, sequential applications of topramezone + triclopyr at 14.6 + 690.4 g a.i. ha^{-1} caused over 50% seashore paspalum injury and reduce turfgrass quality. In our estimation, such programs will likely require manipulation of the topramezone rate, initial application timing, application interval, and number of applications. Further, we have demonstrated that triclopyr is a possible synergist for bermudagrass control that also reduces seashore paspalum injury, at least in the short term. Future research should evaluate strategies to control bermudagrass infestations in seashore paspalum cultivars in the long-term to ensure the complete control of contaminated turfgrass and decrease injury of seashore paspalum.

VIRTUAL MODELS FOR WEED SCIENCE EDUCATION. A. Peart*[1], B. A. Ackley[2]; [1]The Ohio State University, Columbus, OH, [2]Ohio State University, Columbus, OH (31)

ABSTRACT

Virtual models provide a new way to use an old tool – visualization – in the world of weed science. Detailed interactive images have the possibility to someday replace live specimens in the arena of weed identification, along with the possibility of enhancing other educational goals, especially when teaching online or at a distance

WEED SPECIES DIVERSITY IN RAILROAD RIGHT-OF-WAYS. A. W. Osburn*[1], M. Loux[2], E. E. Regnier[1], K. Harrison[2]; [1]The Ohio State University, Columbus, OH, [2]Ohio State University, Columbus, OH (32)

ABSTRACT

Abstract:

Vegetation control along railroad right-of-ways is a ubiquitous practice within the United States. Many methods are employed to achieve control, but herbicide application is the most efficient and economical. Due to varied herbicide treatment programs, strong selective pressures may be exerted upon weed species present in railway environments, leading to selection for tolerant species and resistant biotypes. There has been little previous research on the impact of intensive herbicide use on railway species diversity, seedbanks, and peripheral environments. The goal of this research was to gain a better understanding of seedbanks near railroad crossing right-of-ways, with the following specific objectives: 1) determine the difference in plant species diversity between areas treated most heavily with herbicides (crossing control) and those receiving less intensive herbicide treatment (roadbed control); 2) determine the difference in plant species diversity between urban and rural railroad crossings; and 3) characterize the plant populations present for their response to glyphosate. At each crossing, soil was sampled to a depth of 5cm in the crossing zone (high intensity herbicide treatment) and roadbed zone (moderate intensity herbicide treatment). Seedbanks were characterized by germination assays in the greenhouse. Preliminary results for the seedbank show that roadbed control sites did not differ in diversity from crossing control sites, based on Shannon's Index (H) = 1.55 (0.13) and H = 1.36 (0.15), respectively. Urban sites had greater diversity H = 1.65 (0.12), than rural sites, H = 1.26 (0.13). Application of glyphosate at 1.5 kg ae/ha controlled most species that grew in soil samples, with some exceptions, notably horseweed and waterhemp. Seed was collected from the surviving plants, and these populations will be screened again for response to several herbicide sites of action to characterize herbicide resistance.

EFFECTS OF IRRIGATION WATER QUALITY ON THE PARTITIONING OF SAFLUFENACIL, INDAZIFLAM, AND PENOXSULAM IN TWO CALIFORNIA ORCHARD SOILS. K. Martin*[1], B. Hanson[2]; [1]University of California, Davis, Davis, CA, [2]University of California, Davis, Winters, CA (33)

ABSTRACT

Reductions in surface water allocations during recent drought conditions resulted in a greater dependence on groundwater resources for orchard irrigation in many regions in California. Groundwater quality can vary dramatically depending on where it is drawn from the water table – lower water levels typically increase salinity and often increase the pH. Influence of soil properties such as moisture, CEC, pH, and organic matter content on herbicide efficacy have been widely studied as have the effects of water quality on herbicide tank mix performance. However, limited studies on the effects of irrigation water quality effects on herbicide desorption have been done. This project evaluates the effects of water pH and salinity on saflufenacil, indaziflam, and penoxsulam partitioning into loam and sand soils from California orchards. A three-way factorial experiment was designed by dosing each soil type with four herbicide rates between 0.1 and 10 times the field rate and extracting the herbicide from soil using water adjusted to four pH levels between pH 5 and pH 8 or four water conductivity levels between 0.5 and 5 dS/m. The soil extraction method was adapted from ASTM method E1195-87 for sorption constant determination; the extracts were analyzed using liquid chromatography coupled with an Orbitrap™ mass spectrometer. In general, low water salinity caused more herbicide to partition out of the soil and water pH had varying effects on the individual herbicides.

DIFFERENCES IN BIOAVAILABILITY OF ATRAZINE, TOPRAMEZONE AND MESOSULFURON-METHYL TO SENSITIVE SPECIES ACROSS VARYING SOIL TEXTURES. S. S. Ramanathan*[1], T. Gannon[1], A. Locke[2], W. Everman[1]; [1]North Carolina State University, Raleigh, NC, [2]USDA-ARS and North Carolina State University, Raleigh, NC (34)

ABSTRACT

Differences in herbicide bioavailability play a determining factor in their potential to cause carryover damage to sensitive crop species in varying soils. A soybean (*Glycine max*) variety, 'Paranagoiana' was selected for a greenhouse experiment to study the differences in bioavailability of atrazine, mesosulfuron-methyl and topramezone in three North Carolina soils with varying sand, clay, silt and organic matter content. Evaluated eight rates of atrazine ranged between 0.04 and 2.15 kg ai ha^{-1}, mesosulfuron-methyl rates ranged between 6.00e-6 and 0.03 kg ai ha^{-}and topramezone rates ranged between 1.68e-7 and 0.04 kg ai ha^{-1}. The rates were selected as percentages of the 1x application rate and as multiples of the average estimated potential carryover concentration of each herbicide across the selected soils that were calculated using data from a previous persistence study. The top 5 cm of soil was treated with one of three herbicide rates and packed into pots (15 cm diameter) containing untreated soil to simulate a carryover scenario while control pots were filled entirely with untreated soil. Two soybean seeds were planted per pot at 1.25 cm depth and the plants were thinned to one after emergence. Each herbicide rate combination was replicated four times and arranged in a randomized complete block design. Height measurements and visual estimates of injury were collected 7, 14, 21 and 28 days after emergence (DAE). Ensuing data collection at 28 DAE, plants were destructively harvested for shoot fresh and dry mass data. These were converted to a percentage of the nontreated within a replicate. These data are represented as dose-response curves to estimate the injury threshold of soybean to the herbicide rates. Data from 28 DAE suggest atrazine applied at 24% of the 1x application rate (0.54 kg ai ha^{-1}) was the lowest rate at which plant death was observed in 'Candor' sand. 32% of atrazine (0.72 kg ai ha^{-1}) was the lowest rate at which plant death was observed in 'Creedmoor' sandy loam. The extent of chlorosis increased and shoot dry biomass decreased in atrazine rates greater than 32% in 'Portsmouth' sandy loam but none of the treated plants showed death in this soil. Extreme leaf distortion, internode shortening, and 45% decrease in shoot biomass compared to control plants were observed in 'Candor' sand treated with 76% of the 1x application rate of mesosulfuron-methyl (0.01 kg ai ha^{-1}). Plants in 'Creedmoor' sandy loam treated with the same rate of mesosulfuron-methyl exhibited slight leaf distortion and 20% decrease in shoot biomass and plants in 'Portsmouth' sandy loam exhibited slight leaf distortion with 7% decrease in shoot biomass. Mesosulfuron-methyl symptoms increased, and shoot biomass decreased in higher rates but at varying degrees in the different soils. Decolorization gradually worsened and shoot biomass decreased in 'Candor' sand with increase in treatment rate of topramezone from 14% (3.36e-3 kg ai ha^{-1}). At 182% of the 1x application rate of topramezone (0.04 kg ai ha^{-1}), plants showed 40% decrease in shoot dry biomass. 'Creedmoor' sandy loam and 'Portsmouth' sandy loam treated with 182% topramezone caused very mild decolorization with 6% decrease in shoot biomass in 'Creedmoor' sandy loam and 5% decrease in 'Portsmouth' sandy loam. Results from this experiment suggest site specific soil characteristics play a crucial role in soil herbicide bioavailability as plant injury varied widely across soils within a single herbicide rate combination. It maybe hypothesized that observed differences are due to varying proportions of sand, silt, clay and organic matter and the inherent characteristics of soil properties to affect herbicide bioavailability. A second experiment will be conducted using alternate sensitive bioassay species, such as radish (*Raphanus raphanistrum*) and canola (*Brassica napus*) to confirm observed differences in soybean response to the three herbicides are due to differences in soil herbicide bioavailability. The persistence of these herbicides in different soils will be correlated with their chemical properties and soil attributes to better understand the relationship between herbicide-soil adsorption, bioavailability and differences in potential for herbicide carryover in varying soils.

RELATIVE DURATION OF RESIDUAL CONTROL AMONG PREEMERGENT HERBICIDES. B. Sperry*[1], D. B. Reynolds[2], J. Ferguson[2], J. A. Bond[3], G. Kruger[4], A. Brown-Johnson[5]; [1]Mississippi State University, Starkville, MS, [2]Mississippi State University, Mississippi State, MS, [3]Delta Research and Extension Center, Stoneville, MS, [4]University of Nebraska-Lincoln, North Platte, NE, [5]Mississippi State Chemistry Laboratory, Mississippi State, MS (35)

ABSTRACT

Weed resistance to POST herbicides has expanded in recent years resulting in increased reliance on PRE herbicides in many cropping systems. However, PRE herbicides do not all provide the same duration of control and require sequential applications at different times. Traditionally, sequential applications of PRE herbicides are initiated based on weed emergence requiring a POST herbicide in sequential applications to control emerged weeds. Ideally, sequential residual applications should be applied prior to weed emergence to maintain constant control; however, this time point is generally unknown due to a plethora of environmental factors. Consequently, time series experiments were conducted across four site-years in Mississippi and Nebraska in effort to quantify the duration of residual Amaranthus control of commonly used PRE herbicides in the US. Acetochlor, S-metolachlor, pyroxasulfone, flumioxazin, clomazone, pendimethalin, dicamba, 2,4-D, isoxaflutole, metribuzin, fomesafen, mesotrione, and fluometuron were applied at standard use rates under fallow conditions and Amaranthus control, was evaluated weekly for 70 days. Data were fit to a nonlinear regression model to estimate time to 90% Amaranthus control. Time to 90% Amaranthus control was shortest for dicamba and 2,4-D resulting in durations of 7 and 5 DAT, respectively. Pyroxasulfone and fluometuron provided the longest duration of Amaranthus control which did not drop below 90% for the duration of the experiment. Time to 90% Amaranthus control for all other herbicides ranged from 29 to 48 DAT. Weed biomass 70 DAT was greatly reduced from acetochlor, S-metolachlor, pyroxasulfone, mesotrione, fluometuron, and fomesafen treatments which ranged from 0 to 50 g 0.33 m^{-2}. While 2,4-D, dicamba, and pendimethalin treatments reduced weed biomass 70 DAT compared to the nontreated, weed biomass was still 220 to 275 g 0.33 m^{-2}. These data indicate that for most residual herbicides, sequential residual applications should be made approximately 28 days apart; however, some herbicides persist longer allowing for increased time between applications.

CLASSIFICATION OF WEEDS IN ROW CROPS USING UNMANNED AERIAL SYSTEMS. B. B. Sapkota*, V. Singh, D. Cope, M. V. Bagavathiannan; Texas A&M University, College Station, TX (36)

ABSTRACT

In recent years, Unmanned Aerial Systems (UAS) have emerged as an innovative technology to provide spatio-temporal information about existing weed species and their density in crop fields. Such information is a critical input for any site-specific weed management program. A multi-rotor UAS (Phantom 4 pro) equipped with an RGB (three bands: red, green, blue) sensor was utilized to collect RGB imagery with a spatial resolution of 0.8cm/pixel. Three weed species, morningglory (*Ipomoea* sp.), Palmer amaranth (*Amaranthus palmeri* S. Wats.), and red sprangletop (*Leptochloa mucronata* Michx.) were broadcast planted in a cotton field (*Gossypium hirsutum* L.) at three different density levels (high, medium, and low) with 3 replications. Within each plot, quadrats (2×2 m) were laid out to collect ground-based weed density. The imageries were preprocessed and the Hough transformation technique was applied to delineate cotton rows. Following the separation of inter-row vegetation from crop rows, multi-level classification coupled with machine learning algorithms were used to distinguish intra-row weed species from cotton. Overall accuracy levels of 88, 90, and 94% were achieved for detecting weed species in high, medium, and low density plots, respectively. Field measured weed density levels were fairly correlated (r^2_0.79) with image-based weed coverage estimation based on data from 46 quadrats. Among the two weed species evaluated, Palmer amaranth showed the highest correlation (r^2=0.96), compared to red sprangletop (r^2=0.87). Results highlight the utility of UAS borne RGB imagery for early- to mid-season weed detection in crop fields, facilitating the precision weed management.

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FIELD EVALUATION OF 2,4-D AND DICAMBA FORMULATIONS ON COTTON AND SOYBEAN RESPONSE. J. T. Buol*, D. B. Reynolds; Mississippi State University, Mississippi State, MS (37)

ABSTRACT

Field evaluation of 2,4-D and dicamba formulations and glyphosate presence on cotton and soybean response.

JT Buol and DB Reynolds

Increased use of 2,4-D and dicamba has led to multiple reports of auxin-herbicide injury on susceptible cultivars following off-target deposition of auxin herbicides, often involving sub-lethal concentrations. While only a limited number of 2,4-D or dicamba products are/may be labeled for use in these systems, multiple other products are available to producers. Glyphosate is still commonly used as a POST herbicide and is available as a tank- or pre-mix herbicide in both the Enlist™ and XTEND® systems. Studies were conducted at six locations in Mississippi from 2015 to 2018 to determine the effect of auxin herbicide product formulation and glyphosate presence on auxin-susceptible, glyphosate-tolerant cotton and soybeans following exposure to a sub-lethal concentration of 2,4-D or dicamba with or without glyphosate. Both auxin formulation and glyphosate presence affected crop response. The presence of glyphosate caused up to 20% more yield loss in cotton and 14% in soybeans exposed to auxin herbicides relative to exposure to the auxin herbicide alone. Older 2,4-D and dicamba formulations such as 2,4-D or dicamba DMA caused up to 7% and 28% greater yield reductions than newer formulations in soybeans and cotton, respectively. Minimal differences in crop injury and maturity due to auxin herbicide formulation were observed, although reductions in height due to herbicide formulation and glyphosate presence mirrored the trends in yield reductions.

RESPONSE OF DICAMBA-RESISTANT KOCHIA TO DICAMBA APPLIED PREEMERGENCE. R. Yadav*[1], P. Jha[1], V. Kumar[2], S. Leland[1]; [1]Montana State University, Huntley, MT, [2]Kansas State University, Hays, KS (38)

ABSTRACT

Dicamba is commonly used to control glyphosate- and ALS-resistant kochia (*Bassia scoparia*) in cereals and corn. The recent release of Roundup Ready 2 Xtend® soybean will allow growers to use dicamba to control glyphosate-resistant (GR) kochia in soybean. However, due to the occurrence of dicamba-resistant (DR) kochia in the US Great Plains region, dicamba POST may not be effective in controlling DR kochia populations in Xtend® soybean. Dicamba is also recommended for use as PRE in Xtend soybean, but there is very limited information available on the response of DR kochia to dicamba PRE applied alone or in conjunction with other herbicide programs in soybean. To fulfill these goals, two separate field experiments were conducted in 2018 at the Montana State University Southern Agricultural Research Center, Huntley, MT to evaluate the response of DR kochia to dicamba applied PRE. In the first experiment, efficacy of dicamba was evaluated against DR kochia in Roundup Ready 2 Xtend® soybean. Dicamba (280 g ae ha^{-1}) with pyroxasulfone (77 g ai ha^{-1}) PRE program improved kochia control to 95% compared with 70% control with dicamba or pyroxasulfone alone at 10 weeks after PRE. A separate dose-response study was conducted in the field with eight doses of dicamba PRE against dicamba-susceptible (DS) and DR kochia. A four parameter log-logistic model was used to generate dose-response curves and GR_{50} values (dose required to achieve 50% reduction in density or biomass). The GR_{50} values for density and shoot dry weight (% of nontreated) of DR kochia (412 and 504 g ae ha^{-1}, respectively) were consistent with those of DS kochia (328 and 399 g ae ha^{-1}, respectively). In conclusion, dicamba PRE can be effectively used to manage DR kochia seed bank in Xtend® soybean.

LEPTOCHLOA ACUMINATA FLOODING TOLERANCE IN CALIFORNIA WATER SEEDED RICE. K. E. Driver*, A. Godar, K. Al-Khatib; University of California, Davis, Davis, CA (39)

ABSTRACT

Bearded sprangletop (*Leptochloa acuminata)* is a problematic weed in California rice production. Flooding was thought to suppress bearded sprangletop germination, emergence, and growth; however after many years of continuous rice production, anecdotal evidence suggests that bearded sprangletop populations can tolerate flood pressures. A study was conducted over two years at the Rice Research Station in Biggs, CA to test the flooding tolerance of two bearded sprangletop populations against three irrigation depths. The study implemented a split block factorial design with sprangletop population being factor 1 and irrigation method being factor 2. The irrigation methods were 1) 5 cm flood; 2) 10 cm continuous flood and; 3) 20 cm continuous flood. The two bearded sprangletop populations tested consisted of one clomazone resistant and one susceptible population. There was no emergence of bearded sprangletop in the 20 cm flood depth of either population. Both populations emerged in the 5 cm flood depth. With a 10 cm flood, only the resistant population survived flooding pressure and produced significantly more tillers and seed than any other treatment-population combination tested. This suggests that there may be a fitness advantage related to clomazone resistance and that populations of bearded sprangletop have adapted to flood pressure.

RELATIVE UPTAKE OF ORGANIC AND INORGANIC NITROGEN IN EIGHT COMMON WEED SPECIES. N. D. Warren*[1], E. A. Hobbie[1], J. Chen[2], R. G. Smith[1]; [1]University of New Hampshire, Durham, NH, [2]International Atomic Energy Agency, Seibersdorf, Austria (40)

ABSTRACT

Improving our understanding of the factors mediating belowground competition between crops and weeds could lead to new weed control practices or improve existing strategies. We conducted a 24-hour pulse chase experiment to assess uptake of ^{15}N labeled ammonium and nitrate, and ^{15}N- and ^{13}C-labeled amino acids by common annual weed and crop species. Individual plants were grown semi-hydroponically in sand for 22 days in a greenhouse. Plants were then conditioned on a mixture of nitrate, ammonium, and amino acids, followed by a 24-hour exposure to ^{15}N treatments. After labeling, plants were separated into roots and shoots, and biomass was dried, weighed, ground and analyzed using a stable isotope ratio mass spectrometer. Individual species differed in their uptake and assimilation of the three nitrogen forms. All species acquired all three forms of N, while ^{13}C patterns from dual labeled amino acids suggest that intact organic N was taken up by most of the species. Wild oats (*Avena sativa* L.) and barnyard grass (*Echinochloa crus-galli (L.) P. Beauv.*) demonstrated a preference for amino acids relative to other species. Lambsquarters (*Chenopodium album* L.) and redroot pigweed (*Amaranthus retroflexus* L.) had strong affinities for nitrate and the potential for increased nitrate reductase activity in their shoots. Wild oats, giant foxtail (*Setaria faberi Herrm.*), and barnyard grass took up comparatively higher amounts of ammonium. The crop species, sorghum-sudangrass (*Sorghum bicolor (L.) Moench ssp. drummondii (Nees ex Steud.) de Wet & Harlan*), did not exhibit strong affinities for a single N-form. Our results suggest that organic N may be an important resource for several agriculturally important annual weed species and that both weeds and crops may have the ability to partition N resources. Further research will help clarify the functional outcomes of this partitioning, especially concerning competition.

EFFECT OF CROP CANOPY AND HERBICIDE TREATMENT ON KOCHIA DENSITY AND SEED PRODUCTION. E. G. Mosqueda*[1], A. Kniss[1], N. C. Lawrence[2], P. Jha[3], G. Sbatella[4]; [1]University of Wyoming, Laramie, WY, [2]University of Nebraska-Lincoln, Pullman, WA, [3]Montana State University, Huntley, MT, [4]University of Wyoming, Powell, WY (41)

ABSTRACT

Kochia (*Bassia scoparia*) is an economically important weed in Western North America cropping systems for many reasons, including evolved resistance to numerous herbicide sites of action. Understanding the interactions between weed seedling emergence and crop management practices is imperative in improving weed management strategies, especially for herbicide-resistant weed species. Field studies were conducted in 2014 at four different field sites in Wyoming, Montana, and Nebraska in order to quantify the impact of different crop canopies and herbicide application on kochia density and seed production under field conditions. Crops used in this study were spring wheat, dry bean, sugarbeet, and corn. Herbicide treatments included ALS inhibitors and a non-ALS herbicide effective for kochia control. A known proportion of ALS-resistant kochia was established spring of 2014 prior to imposition of treatments. Kochia density was evaluated mid-way through crop maturity, and kochia seed production was estimated at crop maturity. The effect of crop and herbicide treatment on kochia density and seed production were analyzed using a generalized linear mixed effects model and Tukey-adjusted pairwise comparisons between treatments were made at the alpha=0.05 level. Kochia density was lowest in dry bean (71.8 plants per ha), followed by spring wheat and sugarbeet (77.2 and 414 plants per ha). Corn had highest kochia densities (728 plants per ha). Plots treated with non-ALS herbicide resulted in significantly less kochia (41 plants per ha) than plots treated with a ALS herbicide (998 plants per ha). Spring wheat treated with a non-ALS herbicide prevented kochia seed production, while corn treated with a non-ALS herbicide resulted in 28 germinable seeds per m^{-2}, followed by spring wheat treated with an ALS herbicide which produced 105 germinable seeds per m^{-2}. Highest germinable kochia was found in dry bean and sugarbeet both treated with an ALS herbicide 2,900 and 6,420 seeds per m^{-2} respectively.

COVER CROPS IN ALMOND ORCHARDS: IRRIGATION AND WEED SUPPRESSION. S. C. Haring*[1], C. Crézé[1], A. Gaudin[1], B. Hanson[2]; [1]University of California, Davis, Davis, CA, [2]University of California, Davis, Winters, CA (42)

ABSTRACT

Cover crops have the potential to increase the sustainability and resilience of many cropping systems but need further study for optimization in orchard systems and in dry, Mediterranean climates. By adding winter annual cover crops to orchard alleys, almond growers may take advantage of winter rains while increasing orchard floor cover and providing pollinator forage. Orchard cover crops may also suppress winter weeds through exploitative competition. We planted two five-species mixtures of cover crops in commercial almond orchards in Tehama, Merced, and Kern Counties, representing the range of climatic conditions across the Central Valley of California, and monitored orchard floor vegetation with point intercept transects. Cover crop species included five mustard species in one mix and one grass, two legume, and two mustard species in the other mix. In Tehama County, where water and light were abundant, both cover crop mixes effectively reduced winter weed populations and bare orchard floor compared to standard (i.e. no cover crop) treatments. Cover crop establishment at the Merced and Kern County locations, which had lower winter rainfall and more mature orchard trees, was not sufficient to reduce weed density or diversity, though bare ground was reduced at the Kern County site. No difference in ground cover was observed between treatments at harvest time, indicating that standard management practices (e.g. burndown herbicides, mowing) resulted in effective cover crop termination. Future research will study management factors, such as planting date and rate, termination timing, and irrigation, that contribute to a successful cover crop in almond orchards.

COVER CROP RESPONSE TO RESIDUAL HERBICIDES IN PEANUT AND COTTON ROTATION. K. J. Price*[1], S. Li[1], A. Price[2]; [1]Auburn University, Auburn, AL, [2]USDA-ARS, Auburn, AL (43)

ABSTRACT

Cover crops can provide many benefits to peanut and cotton rotation in terms of suppressing weeds, conserving soil moisture for planting, increasing soil organic matter, and reducing soil erosion. However, in fields where residual herbicides were used during the growing season, establishment of cover crops can be negatively affected by the herbicide residues. The objective of this study was to investigate the responses of six cover crops (daikon radish, cereal rye, cocker oats, crimson clover, winter wheat, and common vetch) to twelve common soil herbicides used in peanut and cotton. A multi-year (2016-2018), multi-location study was conducted in Macon and Henry County in Alabama. Herbicide treatments were applied at 10% of full labelled rate for cotton or peanut at cover crop planting. At 50 and 150 days after planting (DAP), plant heights and stand counts were evaluated as well as wet biomass at 150 DAP. Treatments included *S*-metolachlor, acetochlor, pyroxasulfone, diclosulam, imazapic, chlorimuron ethyl, bentazon plus acifluorfen, pyrithiobac sodium, trifloxysulfuron sodium, diuron, prometryn, flumioxazin, and a non-treated check (NTC). In 2016, significant stand reductions (p0.05) of 30-52% in rye and 22-75% in wheat respectively were observed at 50 DAP for *S*-metolachlor, acetochlor, pyroxasulfone, diclosulam, imazapic, chlorimuron ethyl, and bentazon plus acifluorfen over both locations. Vetch had significant stand reductions for all twelve treatments at 50 DAP

ranging from 12-80% over both locations. *S*-metolachlor, pyroxasulfone and acetochlor had the largest negative impacts on stand counts for rye, wheat and vetch. Daikon radish had significant height reductions of 9, 15, and 31% at 50 DAP for diuron, chlorimuron ethyl, and imazapic, respectively, in Macon County. At 145-149 DAP, all affected cover crops had recovered from herbicide damage and did not show any significant treatment differences in any of the growth parameters evaluated in 2016. In 2017, wheat had a significant stand reduction of 22% for flumioxazin at 42-45 DAP over both locations. At 147-149 DAP, clover had a significantly reduced stands of 29-38% for diclosulam and trifloxysulfuron sodium respectively, over both locations. Radish also had a significantly reduce stand of 64% for diclosulam. Oats, rye and vetch did not have any significant stand reductions at either timing in 2017/2018. Oats showed the most tolerance with no treatments significantly reducing stands or plant heights for either year. Overall, the type of cover crop planted should be based on the residual herbicides applied to row crops the previous season as well as the biomass goal and nutrient needs of the field. Although initial injury and stunting may occur, biomass of those cover crops may not be affected by herbicide residues evaluated in this study.

USING COVER CROPS TO MANAGE *KOCHIA SCOPARIA* IN WHEAT PRODUCTION SYSTEMS OF THE WESTERN UNITED STATES. D. M. Thiemann*[1], S. L. Young[2]; [1]Utah State University, Nibley, UT, [2]University of Nebraska-Lincoln, Ithaca, NY (44)

ABSTRACT

POSTEMERGENCE APPLICATIONS OF OXADIAZON EFFECTIVELY DIAGNOSE RESISTANCE IN *ELEUSINE INDICA*. B. Bi*[1], Q. Wang[1], J. J. Coleman[1], J. S. McElroy[1], J. M. Peppers[2], N. Hall[1]; [1]Auburn University, Auburn, AL, [2]Auburn University, auburn, AL (45)

ABSTRACT

Goosegrass (*Eleusine indica* (L.) Gaertn) is a problematic weed in managed turfgrass in United States. Oxadiazon is a unique protoporphyrinogen oxidase (PPO) inhibitor ultilized for preemergence goosegrass control in various turfgrass and crops. Research was conducted to evaluate response of confirmed preemergence applied oxadiazon-resistant (R1 and R2) and susceptible (S) biotypes to postemergence applications of four different PPO inhibitors-oxadiazon, lactofen, flumioxazin and sulfentrazone. Based on the injury visual score related to non treated, the oxadiazon rate at which damage would be induced 50% (I_{50}) or 90% (I_{90}) ranged from 7.18 to 9.64 kg ha^{-1} or 13.63 to 19.05 kg ha^{-1}, respectively to R1 and R2 biotypes, compare to ranged from 0.05 to 1.18 kg ha^{-1} or 1.13 to 3.24 kg ha^{-1}, respectively to susceptible biotype. All three biotypes were controlled by the other three postemergence herbicides. However, difference in dose-response curves at lower tested rates, sulfentrazone at 0.14 kg ha^{-1} and lactofen at 0.055 kg ha^{-1}, may indicates different response between biotypes at lower rates. No such differences were observed in flumioxazin rates. Results indicate postemergence applications of oxadiazon can be used to evaluate putative resistant populations.

INDAZIFLAM EFFICACY IN THE CONTROL OF DOWNY BROME. T. L. Burke*, I. C. Burke; Washington State University, Pullman, WA (46)

ABSTRACT

Downy brome (*Bromus tectorum* L.) is a problematic weed of many crops, particularly in the Pacific Northwest. Control of downy brome can be difficult to achieve as it avoids management inputs and typically produces seed well before harvest. Indaziflam is a cellulose biosynthesis inhibitor (HRAC group L) of the alkyalzines chemical family and is used for monocot and dicot weed control in permanent crops since its registration in 2010. Despite increased use over time, there have been no instances of weed resistance to indaziflam or any other member of the cellulose biosynthesis inhibitor family. Thus, indaziflam is of interest for the control of problematic weeds, such as downy brome, in multiple systems. Trials to study to long term effects on downy brome populations to five indaziflam doses ranging from 5 to 40 g ai ha^{-1} were started in the spring of 2016 near Davenport, WA. Indaziflam was also applied with pyroxsulam, a postemergence selective herbicide for annual grass control. Control in the first year occurred mainly for indaziflam plus pyroxsulam (>80% at all rates by early summer). In the second year, a dose dependent relationship between rate and control was observed for both treatment types such that a higher application rate of indaziflam resulted in increased control. The highest rate of indaziflam alone was comparable to, or better than the highest mixture treatment rate early in the season (>80% vs >70% for highest rate indaziflam alone vs mixture by early spring and >70% for both by mid spring). However, by late spring the highest rate of the mixture treatment provided the most control in the second year. Less downy brome biomass and thus more control was observed for the mixture treatments compared to both the nontreated and the indaziflam alone treatments. Thus, indaziflam, particularly when mixed with pyroxsulam, was able controlled downy brome well into the second season after application and could be used to reduce or eliminate downy brome from the seed bank.

EXAMINING NEGATIVE PLANT-SOIL FEEDBACK ACROSS CROPPING SYSTEMS FOR NOVEL WEED MANAGEMENT. L. CHENG*[1], J. Kao-Kniffin[1], A. DiTommaso[2]; [1]CORNELL UNIVERSITY, Ithaca, NY, [2]Cornell University, Ithaca, NY (47)

ABSTRACT

The recent advances in sequencing technologies could provide insights into the complex interactions between weed species and soil microbiota that influence weed growth. Specifically, we collected soil samples from common ragweed (*Ambrosia artemisiifolia* L.) in 24 locations with different cropping systems in New York State, and examined plant-soil feedback effects in a greenhouse experiment. Microbiomes from the 24 farm soils were added to replicated pots containing ragweed seedlings. Mature plants were removed and the soils were re-planted with new seedlings to simulate a plant-soil feedback cycle. A machine-learning algorithm was constructed to create a supervised principal components analysis (PCA) of bacterial 16S rRNA gene sequences derived from Pearson correlations linking microbial taxa with weed growth. Distinct microbial fingerprints emerged that separated conventional and organic cropping systems by weed suppression level. A large proportion of the most highly suppressive microbiomes were derived from conventional farms, whereas the microbiomes resulting in positive growth, neutral, or weak suppression of ragweed originated largely from organic farms. The sequencing data revealed that levels of negative plant-soil feedback were influenced by farm management, which suggests that the soil microbiota associated with surviving populations of ragweed inhibits the growth of the successive cycle of ragweed plants in conventional farms. Further investigations of these highly suppressive microbiomes using laboratory cultivation techniques and activity-based metagenomics could reveal specific biological agents and natural products that may be suitable for weed management.

USE OF TRIFLUDIMOXAZIN ALONE AND WITH VARIOUS TANK-MIX PARTNERS FOR FOLIAR CONTROL OF GIANT RAGWEED (*AMBROSIA TRIFIDA*).
N. R. Steppig*[1], S. Willingham[2], D. M. Whalen[3], B. G. Young[4]; [1]Purdue University, Lafayette, IN, [2]BASF, Seymour, IL, [3]University of Missouri, Columbia, MO, [4]Purdue University, Brookston, IN (48)

ABSTRACT

Giant ragweed (*Ambrosia trifida*) is a summer annual broadleaf weed found across much of the crop-producing areas of North America. Crop yield reduction as a result of competition with giant ragweed can be substantial, with densities of only one plant m^{-2} causing losses in excess of 75% in soybean. As such, controlling this problematic weed is essential for maximizing crop yields. However, giant ragweed's rapid growth, discontinuous germination pattern, and resistance to glyphosate and ALS-inhibiting herbicides makes it particularly difficult to control. Trifludimoxazin is a PPO-inhibiting herbicide currently under development by BASF Corporation, which has been reported to have activity on ragweed species; however, there is a lack of published data describing the extent of control, or the potential for interactions with other herbicides when tank-mixed. Therefore, research was conducted near Lafayette, Indiana in 2017 and 2018, in order to examine trifludimoxazin activity alone (12.5 and 25 g ai ha^{-1}), and in combination with the herbicides glufosinate (593 g ae ha^{-1}), glyphosate (870 g ae ha^{-1}), paraquat (840 g ai ha^{-1}), and saflufenacil (25 g ai ha^{-1}). Herbicide applications were made when giant ragweed were 20 to 25cm in height, and four plants in each plot measuring 23cm were marked prior to application. Applications of 12.5 and 25 g ai ha^{-1} trifludimoxazin alone resulted in 77 and 79% giant ragweed control in the marked plants at 21 days after application (DAA). With the exception of the treatment containing only glyphosate, all other treatments resulted in ≥99% control of the marked plants at 21DAA. Biomass measurements were taken from the marked plants in each plot and data were subjected to Colby's analysis, which revealed the interaction between all tank-mix combinations to be additive in nature. These results suggest that applications of trifludimoxazin alone can provide activity on large (up to 25cm) giant ragweed plants, and that tank-mixtures of trifludimoxazin and the four herbicides evaluated can increase this activity.

MANAGEMENT OF PERENNIAL GRASS SSP. IN LOUISIANA RICE PRODUCTION.
D. C. Walker*[1], E. P. Webster[1], B. McKnight[1], S. Rustom[1], C. Webster[2]; [1]Louisiana State University, Baton Rouge, LA, [2]Louisiana State University, Baton Rouge, AL (49)

ABSTRACT

Management of Perennial Grass ssp. in Louisiana Rice (*Oryza sativa* L.) Production. D.C. Walker*, E.P. Webster, B.M. McKnight, S.Y. Rustom, M.J. Osterholt and L.C. Webster. Louisiana State University.

ABSTRACT

In Louisiana, the climate is sub-tropical which provides suitable conditions for a wide variety of perennial grass species. Brook crowngrass (*Paspalum acuminatum* Raddi.), creeping rivergrass (*Echinochloa polystachya* Kunth Hitchc.) and southern watergrass (*Luziola fluitans* Michx.) are C_4 perennial aquatic grasses that thrive in a sub-tropical climate and have proven to be problematic for rice growers in Louisiana. The control of these grasses is essential and if left unchecked, can pose a significant threat to rice production. With the release of new herbicides for postemergence weed control in rice, it is important to evaluate the activity of these new herbicides on these perennial grasses.

The objective of this research was to evaluate early season control of brook crowngrass, creeping rivergrass and southern watergrass with four different herbicides in a drill-seeded rice production system. A separate trial was conducted for each of the three aforementioned grass species. Trials were conducted in 2018 at the Louisiana State University AgCenter's H. Rouse Caffey Rice Research Station near Crowley, LA. Provisia rice cultivar "PVL01" was drill-seeded in 1.5 x 5.2 m plots. For each trial, the respective weed species was transplanted at a density of 2 plants per m^{-2}. Treatments consisted of a single application of quizalofop at 77, 100, 119, or 139 g ai ha^{-1}; florpyrauxifen-benzyl at 29 g ai ha^{-1}; penoxsulam at 40 g ai ha^{-1} or bispyribac at 28 g ai ha^{-1}.

Results indicated none of the evaluated herbicides provided adequate control of brook crowngrass at 42 DAT with 45% control from 139 g ai ha^{-1} of quizalofop and 23% control with florpyrauxifen-benzyl applied at 29 g ai ha^{-1} and penoxsulam applied at 40 g ai ha^{-1}. Therefore, cultural control methods such as increased tillage, combined with a preemergence herbicide application may be required to adequately control brook crowngrass. However, creeping rivergrass and southern watergrass was consistently controlled at 42 DAT when treated with all rates of quizalofop resulting in 83 to 96% control.

WEED CONTROL AND ECONOMIC RETURNS OF HERBICIDE SYSTEMS.
J. J. Williams*[1], D. Dodds[1], L. X. Franca[1], B. Norris[2], S. Davis[2], J. P. McNeal[3]; [1]Mississippi State University, Mississippi State, MS, [2]Mississippi State University, Starkville, MS, [3]Mississippi State University, Mississippi State, Mississippi, MS (50)

ABSTRACT

EVALUATING THE REPRODUCTIVE CAPACITIES OF SELECT MULTIPLE HERBICIDE-RESISTANT *AMARANTHUS TUBERCULATUS* POPULATIONS.
E. A. Jones*[1], M. D. Owen[2], R. Leon[1], W. Everman[1]; [1]North Carolina State University, Raleigh, NC, [2]Iowa State University, Ames, IA (51)

ABSTRACT

Plant defense traits such as herbicide resistance mutations may incur a fitness cost to plants that become evident when the trait is not needed. However, individuals with multiple-herbicide-resistance traits may decrease fitness beyond that of plants with a single herbicide resistance mutation. Multiple herbicide-resistant (MHR) *Amaranthus tuberculatus* populations are becoming more prevalent in Midwest United States agroecosystems. The objective was to determine if selected MHR *A. tuberculatus* populations express differential seed size and production when grown in a herbicide-free environment. The hypothesis was that MHR *A. tuberculatus* populations become produce smaller and less seeds when additional herbicide resistances evolve. MHR and herbicide-susceptible *A. tuberculatus* populations were grown in a herbicide-free field for 20 weeks for two seasons. Seed production was different amongst *A. tuberculatus* populations ($P = 0.001$), but was not influenced by the number of MHR traits. Conversely, a negative quadratic relationship between seed mass and the number of MHR traits was observed ($r^2 = 0.32$; $P < 0.001$). The experiment results demonstrate that MHR in *A. tuberculatus* populations does not affect seed production but increasing herbicide resistance traits reduces seed size that could be managed to select these populations out of the agroecosystem.

EFFECT OF FLOODING PERIOD AND SEED BURIAL DEPTH ON PALMER AMARANTH (*AMARANTHUS PALMERI*) SEED GERMINATION. L. X. Franca*[1], D. Dodds[1], S. Davis[2], J. P. McNeal[3], J. J. Williams[2], B. Norris[2]; [1]Mississippi State University, Mississippi State, MS, [2]Mississippi State University, Starkville, MS, [3]Mississippi State University, Mississippi State, Mississippi, MS (52)

ABSTRACT

Palmer amaranth (*Amaranthus palmeri* S. Wats.) is an extremely prolific seed producer with a single female plant capable of producing up to 600,000 seeds per plant under favorable conditions. Palmer amaranth seed production of 312,000 and 500,000 seeds per plant has been reported when plants were competing with soybeans and cotton, respectively. Seed germination and viability is dependent on factors such as soil moisture, oxygen availability and quality, temperature, light exposure, microbial activity, and burial depth. Flooding conditions create an unfavorable environment for most weed species, which typically results in reduced seed germination and emergence. Flooding is a common practice in most rice (*Oryza sativa* L.) fields in the Lower Mississippi Alluvial Valley (Mississippi Delta). Fall-winter flooding is an effective practice for rice straw decomposition and waterfowl habitat. Nevertheless, limited research is available regarding the effects of fall-winter flooding and seed burial depth on Palmer amaranth seed germination in Mississippi.

Experiments were conducted in 2016 and 2017 at the R. R. Foil Plant Research Center in Starkville, MS to evaluate the effect of flooding period and seed burial depth on Palmer amaranth seed germination. Flood simulation was conducted using 27 L buckets containing 30 cm of soil plus 15 cm of water. 500-micron pore opening polyethylene mesh bags measuring 64 cm^2 containing 20 grams of sterilized soil were used to store 100 Palmer amaranth seeds for the duration of the experiment. Three soil textures were used, a Leeper silty clay loam, a Dundee silty loam, and a Brooksville silty clay. Mesh bags were placed at soil surface as well as buried at 15 cm depth and subjected to six flooding periods which included, no-flooding, 1 month (October), 2 months (October-November), 3 months (October-December), 4 months (October-January), and 5 months (October-February). Following each flooding period, seeds were removed from the experimental area, enumerated under a microscope, and characterized as normal or damaged. Following characterization, seeds were germinated in a growth chamber under 35-30°C day-night temperature cycles and 14-10 hour day-night regimes. Seeds were considered germinated when radicle length was equal or longer than 1 mm. Data were subjected to analysis of variance using PROC MIXED procedure in SAS® v. 9.4 and means were separated using Fisher's Protected LSD at α=0.05.

Flooding periods of 4 and 5 months resulted in the greatest amount of damaged Palmer amaranth seeds ($p < 0.0001$). Flooding reduced total Palmer amaranth seed germination, regardless of flooding regime ($p < 0.0001$). Additionally, flooding periods of 4 and 5 months provided the greatest reduction of Palmer amaranth seed germination. No differences on Palmer amaranth seed germination were observed due to soil texture ($p = 0.1470$). Palmer amaranth seed viability was significantly greater when buried at 15.2 cm compared to 0 cm in no-flooding conditions ($P \leq 0.0001$). However, seed burial did not affect Palmer amaranth germination in flooded treatments.

INVESTIGATING PALMER AMARANTH RESISTANCE TO S-METOLACHLOR IN ARKANSAS. J. Kouame*[1], N. R. Burgos[2], C. D. Willett[2], M. B. Bertucci[2], E. M. Grantz[2]; [1]University of Akansas, Fayetteville, AR, [2]University of Arkansas, Fayetteville, AR (53)

ABSTRACT

Investigating Palmer Amaranth Resistance to *S*-Metolachlor in Arkansas

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Abstract. Palmer amaranth is one of the most troublesome weeds in row crop production in Arkansas. Effective postemergence control options are limited. Therefore, farmers rely on preemergence herbicides to manage Palmer amaranth in soybean fields. *S*-metolachlor is one of the most commonly used preemergence herbicides for Palmer amaranth control. However, a few farmers have shared what they thought of as possible reduced efficacy of *S*-metolachlor on Palmer amaranth in Arkansas. The objective of this research was to investigate the response of Palmer amaranth populations from Arkansas to the labeled rate of *S*-metolachlor and to determine the level of tolerance of the least susceptible accessions. Palmer amaranth seeds were collected from 34 fields in 14 counties during Fall 2018. General screening was conducted in the greenhouse using a completely randomized design with three replicates. Thirty-five Palmer amaranth accessions (from 34 fields) were sprayed with 1,120 g ai/ha *S*-metolachlor. A sample collected from an organic field was used as the susceptible standard. Follow-up dose-response studies were conducted with 4 accessions using a randomized complete block design with three replicates and seven rates of *S*-metolachlor (0, 0.15x, 0.3x, 0.5x, 1x, 1.5x, and 2x). The Palmer amaranth accessions differed significantly in susceptibility to *S*-metolachlor. Overall, 14% of accessions were controlled ≤ 88%, 21 days after treatment and 3 accessions were controlled significantly less by the labeled rate of *S*-metolachlor ($p<0.0001$) than the susceptible standard (from an organic field). The effective doses for 50% control (ED_{50}) of the least-susceptible accessions were 448 and 291 g ai/ha while the effective doses for 90% control (ED_{90}) of these accessions are 1,658 and 1,131 g ai/ha, respectively. The two least susceptible accessions were 4.5 and 3-fold more tolerant to *S*-metolachlor than the susceptible standard used in this study. The least susceptible accessions could no longer be controlled 100% with 1,120 g ai/ha *S*-metolachlor.

Key words: Palmer amaranth, *S*-metolachlor, susceptible, tolerance, resistance

PALMER AMARANTH (*AMARANTHUS PALMERI*) AND THRIPS (*THRIPS SP.*) CONTROL WITH VARIOUS DICAMBA + INSECTICIDE TANK-MIXES IN COTTON (*GOSSYPIUM HIRSUTUM*). J. P. McNeal*[1], D. Dodds[2], A. L. Catchot[3], S. Davis[3], L. X. Franca[2], B. Norris[3], J. J. Williams[3]; [1]Mississippi State University, Mississippi State, Mississippi, MS, [2]Mississippi State University, Mississippi State, MS, [3]Mississippi State University, Starkville, MS (54)

ABSTRACT

A field experiment was conducted to evaluate the effect of carrier volume and spray droplet size on the efficacy of dicamba + insecticide tank mixtures to control Palmer amaranth (*Amaranthus palmeri*) and thrips (*Thrips sp.*) in cotton (*Gossypium hirsutum*). This experiment consisted of two field locations: the Delta Research and Extension Center in Stoneville, Mississippi, and Hood Farms in Dundee, Mississippi. Four row plots were planted with a single cotton variety: DP 1646 B2XF, and plot dimensions were 3.9m x 14.2m (Stoneville, MS) and 3.8m x 9.1m (Dundee, MS). Applications were made on 04 and 07 June 2018 in Stoneville and Dundee, respectively. Applications were initiated when cotton reached the 4-leaf growth stage.

Applications were made with a Capstan Pinpoint Pulse-Width Modulation (PWM) sprayer on a high-clearance Bowman Mudmaster at a ground speed of 14.5 km hour^{-1}. A single formulation of dicamba: (XtendiMAX® with VaporGrip) applied at 1.5 kg ha^{-1}, and two insecticides: acephate (Acephate 97UP) applied at 0.2 kg ha^{-1}, and dimethoate (Dimethoate 4EC) applied at 0.4 kg ha^{-1} were chosen. This experiment utilized two carrier volumes: 140 and 280 L ha^{-1} and two droplet sizes: 200μm and 800μm.

Pesticide - Carrier Volume - Droplet Size treatment combinations included [1] dicamba-141 L ha^{-1}-800 μm, [2] dicamba + acephate-141 L ha^{-1}-800 μm, [3] dicamba + dimethoate-141 L ha^{-1}-800 μm, [4] dicamba + acephate-280 L ha^{-1}-800 μm, [5] dicamba + acephate-280 L ha^{-1}-800 μm, [6] acephate-141 L ha^{-1}-200 μm, [7] acephate-141 L ha^{-1}-800 μm, [8] dimethoate-141 L ha^{-1}-200 μm, [9] dimethoate-141 L ha^{-1}-800 μm. Each replication contained both a weed/pest free check in addition to an untreated control.

Visual thrips damage ratings (1-5) and thrips counts (adults and nymphs) were taken at 1, 3, and 7 days after treatment (DAT). Visual Palmer amaranth control (0-100) was evaluated at 7, 14, 21, and 28 DAT, and visual cotton injury (0-100) was rated at 7, 14, and 21 DAT. Seed cotton yield was collected using a spindle picker modified for plot research. Additionally, 25 boll -samples were collected prior to mechanical harvest and ginned on a laboratory micro-gin to determine lint turnout.

The experimental design was a randomized complete block and data were analyzed using PROC MIXED in SAS v. 9.4. Means were separated using Fisher's Protected LSD at an alpha level of 0.05.

At 1, 3, and 7 DAT, thrips counts varied by location but not due to carrier volume, or droplet size. At 1 DAT, adult counts were 44% less in Stoneville ($p = 0.0068$) relative to Dundee, but nymphs were 63% less in Dundee ($p = 0.001$) relative to Stoneville. At 3 DAT, adult and nymph counts were 62% ($p = 0.0126$) and 56% ($p \leq 0.0001$) less in Stoneville relative to Dundee. Finally, at 7 DAT, only nymphs counts varied across location, and were 67% fewer Stoneville ($p = 0.0146$) relative to Dundee.

At 7 DAT, visual Palmer amaranth control varied due to treatment ($p = <0.0001$). All treatments resulted in greater control of Palmer amaranth relative to the untreated control. However, the weed free check resulted in the highest level of control relative to all other treatments.

At 14 DAT visual Palmer amaranth control varied due to treatment ($p = < 0.0001$). All treatments resulted in greater control of Palmer amaranth relative to the untreated control. However, the weed free check resulted in the highest level of control relative to all other treatments.

Seed cotton yield varied by location ($p = \leq 0.0001$) but not due to pesticide, carrier volume, or droplet size. Seed cotton yield was 74% (3240 kg ha^{-1}) and 76% (3293 kg ha^{-1}) higher in Stoneville relative to Dundee in Experiment 1 and 2, respectively.

Our data indicate that thrips counts varied across location, but did not vary due to carrier volume or droplet size and Palmer amaranth control did not vary due to carrier volume or pesticide tank-mix 14 DAT. No treatment resulted in the same level of Palmer amaranth control as the weed free check. Finally, seed cotton yield varied due to location and not due to pesticide, carrier volume, or droplet size. Future research should focus on various dicamba + insecticide tank-mixes for their potential utility in cotton production systems. Furthermore, the potential volatility of dicamba formulations when tank-mixed with an insecticide should be thoroughly investigated.

RESIDUAL CONTROL OF PALMER AMARANTH AS EFFECTED BY COVER CROP AND HERBICIDE. C. M. Perkins*[1], K. Bradley[2], J. K. Norsworthy[3], D. B. Reynolds[4], K. L. Gage[5], S. Steckel[6], B. G. Young[7], L. E. Steckel[6]; [1]The University of Tennessee, Jackson, TN, [2]University of Missouri, Columbia, MO, [3]University of Arkansas, Fayetteville, AR, [4]Mississippi State University, Mississippi State, MS, [5]Southern Illinois University, Carbondale, IL, [6]University of Tennessee, Jackson, TN, [7]Purdue University, Brookston, IN (55)

ABSTRACT

Residual Control of Amaranthus spp. as Effected by Cover Crop and Herbicide

Clay M. Perkins[1]*, K.W. Bradley[2], J.K. Norsworthy[3], D.B. Reynolds[4], K.L. Gage[5], S.J. Steckel[1], B.G. Young[6], and L.E. Steckel[1]

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Palmer amaranth *(Amaranthus palmeri)* and waterhemp *(Amaranthus tuberculatus)* have consistently been the most problematic weed in soybean across the Mid-South and Midwest. Multiple herbicide applications are normally needed due to the ability of these weeds to germinate throughout the growing season, their prolific seed production, and their competitive nature. Using cover crops has helped minimize the number of herbicide applications required by aiding in the prevention of weed emergence. This has led to the question of the potential benefits of using soil residual preemergence (PRE) herbicides in combination with cover crops for early-season control of *Amaranthus spp.* weeds in soybean.

A regional study was conducted across the Mid-South (TN and AR) and Midwest (IN) to evaluate the benefit of the residual activity from the labelled PRE herbicides in a cover crop prior to soybean. Trials were conducted in Fayetteville, AR, Jackson, TN, and Farmland, IN in 2018. The cover crop consisted of cereal rye *(Secale cereal)* 67 kg ha^{-1} + hairy vetch *(Vicia villosa)* 8 kg ha^{-1} planted the preceding fall. Treatments included non-treated (no residual), *S*-metolachlor (1070 g ai ha^{-1}), pyroxasulfone + flumioxazin (160 g ai ha^{-1}), dimethenamid-P (840 g ai ha^{-1}), pendimethalin (1060 g ai ha^{-1}), metribuzin (630 g ai ha^{-1}), flumioxazin (71.5 g ai ha^{-1}), acetochlor (1260 g ai ha^{-1}), and pyroxasulfone (119 g ai ha^{-1}). Plots were 3 m wide and 9.1 m long. Treatments were replicated four times and arranged in a randomized complete block design. Visual control was assessed when Amaranthus spp. reached 10 cm tall and 7 days after Amaranthus spp. reached 10 cm tall, when average heights were then assessed. Data were analyzed using a general linear mixed model analysis of variance PROC Glimmix of SAS (Version 9.4) ($\alpha \leq 0.05$).

In Tennessee, the use of herbicides suppressed Palmer amaranth emergence, on average, by just over two weeks. However, seven days after Palmer reached 10 cm tall, there was no difference between treated and the non-treated plots for weed counts in Tennessee and Arkansas. The PRE applied herbicide treatments flumioxazin, pyroxasulfone + flumioxazin premix, and acetochlor supplemented the weed control provided by the cover crop by reducing the establishment of Palmer and waterhemp compared with the other herbicides tested. Height differences were only evident in Indiana for waterhemp. Despite the improved weed control, no yield differences were detected amongst the two weed species or the three locations. The authors suggest that the reason for the lack of yield response was due to the cover crop reducing the number of Amaranth spp. that emerged and delaying that emergence by 14 days. Several published studies have shown that reducing and delaying Amaranth spp. emergence can mitigate soybean yield loss from competition.

Although all residual herbicides evaluated delayed Palmer amaranth emergence and growth to 10 cm tall, some provided more consistent control than others. These data suggest that adding a soil residual herbicide for control of Palmer amaranth greatly improves the consistency of control in a cover crop system preceding soybean by both delayed and reduced emergence. This can play an important role in herbicide resistance management since fewer weeds are exposed to POST herbicide applications resulting in less selection pressure.

WEED POPULATION HERBICIDE RESISTANCE CONTROL THROUGH SENSITIVE ALLELE GENE SWAMPING *IN SILICO* FOR *AMARANTHUS TUBERCULATUS*.. B. C. Alexander*[1], A. S. Davis[2], A. Hager[3], P. Tranel[4]; [1]University of Illinois, Champaign, IL, [2]N-319 Turner Hall, Urbana, IL, [3]University of Illinois, Urbana, IL, [4]University of Illinois, Urbana, IL (56)

ABSTRACT

High selection pressure imposed by current herbicide management regimes has resulted in a high rate of evolution for herbicide resistance in agricultural weeds. It is reasonable to expect that resistance to other forms of weed control that also impose a high selection pressure, such as the Harrington Seed Destructor, will also result in a high rate of resistance evolution for weed populations. High selection pressure over several years promotes rapid evolution of herbicide resistance partly because there is not enough time for natural gene flow to 'restock' the population with sensitive alleles. Genetic swamping (pollen swamping, seed addition) is a potential method for increasing the proportion of sensitive alleles within a population. We have planned simulation experiments to examine the effect of artificially restocking a population of waterhemp (*Amaranthus tuberculatus*) with sensitive pollen and seed using a published population growth model. We expect that swamping populations with sensitive alleles, combined with integrated weed management, will help create more manageable weed populations by revitalizing older chemistry by increasing the proportion of sensitive alleles within the population.

DETECTION OF ACCASE-INHIBITING HERBICIDE RESISTANCE IN SOUTHERN CRABGRASS (*DIGITARIA CILIARIS*) THROUGH GEL-BOX BIOASSAY. S. Basak*[1], B. Bi[1], A. M. Brown[1], P. McCullough[2], J. S. McElroy[1]; [1]Auburn University, Auburn, AL, [2]University of Georgia, Griffin, GA (57)

ABSTRACT

Detection of ACCase- inhibiting herbicide resistance in southern crabgrass (*Digitaria ciliaris*) through gel-box bioassay

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The Research was conducted to determine if an agar-based gel box bioassay was useful in detecting acetyl CoA carboxylase (ACCase)-inhibiting herbicides. Biotypes of the ACCase-resistant southern crabgrass (R_1 and R_2) were collected from sod production fields in Georgia. A susceptible (S) population with no known history of exposure to any ACCase-inhibiting herbicides was collected from Alabama. The murashigee-skoog (MS) media were prepared and the amount of 65 mL media was added into each plant tissue culture boxes. Five seedlings of southern crabgrass, R_1, R_2, and S phenotypes were transplanted onto agar media containing the discriminating dose of sethoxydim and pinoxaden herbicides (0, 0.1, 0.2, 0.4, 0.8, 1.6, 3.25, 6.5, 12, 25, 50, 100, 200, or 400 µM). Phytotoxicity of each seeding in agar-based gel box was evaluated at 3, 6, and 9 days after treatment. Both R_1 and R_2 were more resistant to sethoxydim than the pinoxaden. The resistant phenotypes showed low phytotoxicity at the lower concentration relative to the susceptible phenotype. At the concentration levels of 100, 200, or 400 µM, all the phenotypes of R_1, R_2 and S showed high phytotoxicity for both herbicides. Sethoxydim rates at which phytotoxicity would be increased by 50% (I_{50}) and 90% (I_{90}) for R_1, R_2 and S ranged from 484.91 to 994.69, 221.34 to 916.07, 172.52 to 705.35 µM, respectively at 3 days, 272.80 to 825.32, 79.99 to 589.62, and 0.76 to 528.43 µM, respectively at 6 days, as well as 10.95 to 959.14, 3.45 to 299.44, and 0.99 to 236.42 µM, respectively at 9 days. The agar-based gel box bioassay is effective in detecting ACCase-resistant field population with target site resistance mechanisms.

CHARACTERIZATION OF THE FUNCTIONAL TRAIT DIVERSITY IN RYEGRASS (*LOLIUM* SPP.) ACCESSIONS COLLECTED FROM TEXAS BLACKLANDS. A. Maity*[1], S. Abugho[1], V. Singh[1], N. Subramanian[1], G. R. Smith[2], M. V. Bagavathiannan[1]; [1]Texas A&M University, College Station, TX, [2]Texas A&M University, Overton, TX (58)

ABSTRACT

Ryegrass (Lolium spp.) shows wide range of adaptability to varied agroclimatic conditions due to its versatile growth habit. It imposes a major threat on wheat production worldwide, including the majority of wheat produced in the Texas Blacklands, though it is also used as a forage, turf and cover crop species. However, information is scarce on the diversity and adaptive characteristics of ryegrass biotypes infesting wheat fields in Texas. Fifty-five ryegrass accessions were collected randomly in wheat production fields across the Texas Blacklands region and were assessed for various seed and plant morphological traits such as hundred seed weight, seed length, awn length, number of tillers, regrowth rate after clipping, node color, leaf color and width, and panicle and spikelet type. Seed samples represented wide diversity, but the majority of them were *Lolium multiflorum* (Italian ryegrass) with few plants of *L. perenne* (perennial ryegrass) mixed in few accessions. Significant levels of variability were observed for different seed and plant morphological traits evaluated. Information generated from this study will provide a better understanding of different functional traits, which will eventually support improved management tactics as well as cultivar improvement. (muthu@tamu.edu)

CROSS-RESISTANCE TO ALS INHIBITORS IN SMOOTH PIGWEED (*AMARANTHUS HYBRIDUS*) FROM THE CAMPOS GERAIS REGION IN BRAZIL. R. R. Mendes*[1], R. S. Oliveira Jr.[2], V. V. Silva[3], H. K. Takano[4]; [1]State University of Maringa, Maringá, Brazil, [2]Stat University of Maringa, Maringá, Brazil, [3]State University of Maringá, Maringá, Brazil, [4]Colorado State University, Ft Collins, CO (59)

ABSTRACT

The "Campos Gerais" is a 1 million hectares area located south of Capricorn Line, comprehending lands from southern part of São Paulo down to the eastern part of Paraná, in Brazil. The region is an important producer of grains such as soybean in summer and wheat, barley and oats in winter. Along the last three years chlorimuron-ethyl applications have not showed good efficacy to control smooth pigweed (*Amaranthus hybridus*). Our objective was to investigate the possibility of cross-resistance to ALS-inhibitors in smooth pigweed in a suspect population from Campos Gerais. Dose-response experiments were carried out with one suspected (R) population from Tibagi (PR) and other suscepible (S) population sampled from a non-agricultural area. Four ALS-inhibitors were sprayed in dose-response assays: chlorimuron, metsulfuron, imazethapyr and cloransulam. For chlorimuron, both populations, R and S, were treated with 0x, 0.125x, 0.25x, 0.5x, 1x, 2x, 4x and 8x the labeled dose (x=20 g ha^{-1}). For metsulfuron, imazethapyr and cloransulam the S population was treated with 0x, 0.125x, 0.25x, 0.5x, 1x, 2x, 4x and 8x and the R population with 0x, 0.25x, 0.5x, 1x, 2x, 4x, 8x and 16x the labeled dose (2.4, 106 and 24 g ha^{-1}, respectively). The resistance factor (RF) were calculated based GR_{50} R/S ratio 28 days after applications. The R population showed 7.2-fold to chlorimuron and 6.4-fold to metsulfuron relative to S population. For imazethapyr we found low resistance levels (2.0-fold) and a high growth suppression (>90%) with labeled dose treatment. In addition, the R population was considered susceptible to cloransulam (RF<1). The evaluated R-population from Tibagi (PR) is resistant to sulfonylureas herbicides, chlorimuron and metsulfuron, but is low-level resistant to imazethapyr and susceptible to cloransulam. Cross-resistance to ALS inhibitors depend on specific herbicide evaluation.

THE FUNCTION OF CYTOCHROME P450 MONOOXYGENASES IN HERBICIDE BIOACTIVATION AND INACTIVATION. D. W. Brooks*[1], T. Gaines[1], R. L. Nichols[2], F. E. Dayan[1]; [1]Colorado State University, Fort Collins, CO, [2]Cotton Incorporated, Cay, NC (60)

ABSTRACT

The Function of Cytochrome P450 Monooxygenases in Herbicide Bioactivation and Inactivation

Donald Brooks, Todd Gaines, Robert Nichols and Franck Dayan

Abstract

Cytochrome P450 complexes are regarded as a distinct factor in the metabolism of xenobiotics in many plant species. Plants possess several hundreds of P450 monooxygenases that play important roles in normal metabolic processes. However, several of these enzymes also have the capacity to metabolically alter herbicides resulting in bioactivation or inactivation of the molecules. P450 monooxygenases that deactivate phytotoxins are typically involved in imparting natural tolerance to herbicides. However, changes in expression of these enzymes have been involved in plants that have evolved non-target site resistance (NTSR). On the other hand, these enzyme complexes are also involved in the bioactivation of herbicides, as demonstrated by the metabolic activation of the pro-herbicide clomazone into its active metabolite 5-ketoclomazone. In spite of the great diversity in the number of P450 monooxygenase classes, most of these enzymes share a similar mechanism of action and general heme-containing catalytic domains requiring association with cytochrome P450 reductases. Most enzymes in the cytochrome P450 family act as phase I compounds of metabolism through oxidation, hydroxylation, and reduction properties. Inhibition or manipulation of P450 monooxygenase activity may pave strategies towards new discoveries to prevent the evolution of NTSR or restore the activity of herbicides in plants exhibiting NTSR. These studies will also provide a deeper understanding of the structure-activity relationship between herbicides and cytochrome P450 enzyme interactions. In utilizing these general mechanisms of xenobiotic degradation and transformation, new paths of study can be explored through the alteration of herbicide compounds in the presence of cytochrome P450 enzymes.

WSSA ADVOCATES FOR WEED CONTROLS THAT PROTECT SOYBEAN EXPORT VALUE. C. Moseley*[1], L. Van Wychen[2], H. Curlett[3], J. Schroeder[4], P. D. Laird[5], S. P. Conley[6]; [1]Syngenta, Greensboro, NC, [2]WSSA, Alexandria, VA, [3]APHIS-USDA, Washington, DC, [4]USDA Office of Pest Management Policy, Arlington, VA, [5]Syngenta Crop Protection, LLC, Greensboro, NC, [6]University of Wisconsin, Madison, WI (61)

ABSTRACT

Weeds and weed seeds are a serious phytosanitary concern. Most countries, including the United States, take action when weed seeds are detected in arriving shipments. The importing country may reject, re-export, or destroy the shipment. In the worst case, the country may suspend imports or close the market altogether. Soybeans are one of the United States' top exports. Increases in herbicide-resistant weeds may be contributing to more weed seeds in harvested beans. There are a number of best practices —many of which are already in use here in the United States—that can be applied on farm and by grain handlers to help reduce weed seeds in U.S. soybeans. These practices are being promoted by USDA, WSSA, and other organizations across the country.

EVALUATION OF PREEMERGENCE AND POSTEMERGENCE APPLICATIONS OF METRIBUZIN ON WEED CONTROL PROGRAMS AND CROP SAFETY IN CORN. T. Bararpour*[1], R. R. Hale[2]; [1]Mississippi State University, Stoneville, MS, [2]Mississippi State University, Fayetteville, AR (62)

ABSTRACT

Crop losses from weed interference have a significant effect on net returns for producers. Weed management programs are an essential component of corn (*Zea mays*) production in Mississippi. Weed control in corn relies primarily on the use of herbicides. A field study was conducted in 2018 at the Delta Research and Extension Center, in Stoneville, Mississippi, to evaluate preemergence (PRE) and postemergence (POST) applications of Sencor (metribuzin) in weed control programs and on corn tolerance (crop safety). Corn (Pioneer P1637 YHR) was planted on beds with 102-cm row spacing at a seeding rate of 8 seeds m^{-1} on April 12, 2018 and emerged on April 24. The study was designed as a randomized complete block with 14 treatments and four replications. All herbicide rates are in kg ai ha^{-1}. Treatments were as follows: 1) Dual II Magnum (*S*-metolachlor) at 1.4 + AAtrex (atrazine) at 1.12 PRE followed by (fb) AAtrex at V3-V4; 2) Sencor at 0.31 PRE fb AAtrex at V3-V4; 3) Sencor at 0.21 PRE fb AAtrex at V3-V4; 4) Sencor at 0.16 PRE fb AAtrex at V3-V4; 5) Halex GT (mesotrione + *S*-metolachlor + glyphosate) at 2.22 + AAtrex at V3-V4; 6) Zidua (pyroxasulfone) at 0.12 + Sencor at 0.31 + Armezon (topramezone) at 0.018 + Roundup PowerMax (glyphosate) at 1.26 at V3-V4; 7) Zidua + Sencor at 0.21 + Armezon + Roundup PowerMax at V3-V4; 8) Zidua + Sencor at 0.16 + Armezon + Roundup PowerMax at V3-V4; 9) Sencor at 0.31 + Armezon + Roundup PowerMax at V3-V4; 10) Zidua + Armezon + Roundup PowerMax at V3-V4; 11) Sencor at 0.21 + Armezon + Roundup PowerMax at V3-V4; 12) Sencor at 0.16 + Armezon + Roundup PowerMax at V3-V4; 13) Dual II Magnum + Sencor at 0.21 PRE fb AAtrex at V3-V4; 14) Dual II Magnum + Sencor at 0.21 PRE fb Halex GT at V3-V4; 15) weed-free check; and 16) nontreated check. All herbicide applications at V3-V4 had crop oil concentrate (COC) at 1% (v/v) and were applied on May 14.

There was no corn injury from any herbicide applications by 10 WAE. All herbicide treatments provided 91 to 100% control of hemp sesbania (*Sesbania herbacea*), pitted morningglory (*Ipomoea lacunosa*), and prickly sida (*Sida spinosa*). Barnyardgrass (*Echinochloa crus-galli*) control was 93, 80, 78, 73, 84, 91, 93, 83, 72, 93, 67, 83, 93,

and 93% from the application of treatments 1 through 14, respectively (10 WAE). The application of treatments 1 through 14 provided 84, 76, 75, 79, 85, 92, 89, 83, 74, 90, 60, 70, 86, and 93% control of broadleaf signalgrass (*Urochloa platyphylla*), respectively. Palmer amaranth (*Amaranthus palmeri*) control was 96, 99, 91, 94, 95, 90, 98, 88, 76, 90, 87, 68, 98, and 94% from the application of treatments 1 through 14, respectively by 10 WAE. Plots received treatments 1 through 15 provided 10,360, 9,479, 14,428, 10,275, 13,247, 15,032, 12,840, 12,023, 12,888, 10,993, 13,792, 12,849, 12,743, 12,649, and 17,539 (weed-free check) kg ha^{-1} corn yield (not significant). Weed interference (nontreated check) reduced corn yield 78% as compared to weed-free check. Therefore, Sencor could be used in weed management programs in Mississippi corn.

EFFECTIVE HERBICIDE PROGRAMS FOR MANAGING GLYPHOSATE-RESISTANT PALMER AMARANTH IN ROUNDUP READY 2 XTEND SOYBEAN. V. Kumar*[1], R. Liu[1], T. Lambert[2], D. Peterson[3]; [1]Kansas State University, Hays, KS, [2]Kansas State University, hays, KS, [3]Kansas State University, Manhattan, KS (63)

ABSTRACT

Glyphosate-resistant (GR) Palmer amaranth (*Amaranthus palmeri*) is a serious concern for soybean growers in mid-south and central United States, including Kansas. The recent commercialization of Roundup Ready^{Ò} 2 Xtend soybean will allow producers to use low-volatile formulations of dicamba for controlling GR weeds, including Palmer amaranth. The main objective of this study was to evaluate and develop effective herbicide programs for managing GR Palmer amaranth in Roundup Ready^{Ò} 2 Xtend soybean. Field experiments were conducted in 2018 at Kansas State University Agricultural Research Center (KSU-ARC) near Hays, KS and Ashland Bottoms (KSU-AB) research fields near Manhattan, KS. The study was established in no-till wheat stubble at Hays location; whereas, the Manhattan site was under conventional tillage system. Eleven different herbicide programs, including PRE alone (premixes with multiple sites of action), PRE fb POST, POST alone, and POST fb POST were evaluated. All POST treatments were a mixture of glyphosate at 1260 g ha^{-1} and dicamba (Engenia^{Ô}) at 560 g ha^{-1}. Treatments were arranged in a randomized complete block design, with four replications. The Manhattan site had a natural infestation of GR Palmer amaranth; whereas, a seedbank of GR Palmer amaranth was uniformly established at Hays site. A single PRE application of sulfentrazone + s-metolachlor, saflufenacil + imazethapyr + pyroxasulfone, chlorimuron + flumioxazin + pyroxasulfone, and metribuzin + flumioxazin + imazethapyr provided 77 to 96% and 86 to 89% control of GR Palmer amaranth at Hays and Manhattan site, respectively, at 9 weeks after PRE (WAPRE). All PRE fb POST treatments had excellent control (³ 95%) of GR Palmer amaranth at 9 WAPRE across both sites. Consistent with visual control, GR Palmer amaranth biomass at soybean harvest was reduced by ³ 89% with all PRE fb POST treatments. However, PRE applied sulfentrazone + s-metolachlor, saflufenacil + imazethapyr + pyroxasulfone, chlorimuron + flumioxazin + pyroxasulfone, and metribuzin + flumioxazin + imazethapyr reduced GR Palmer amaranth biomass by 34 to 72% and 56 to 76% at Hays and Manhattan sites, respectively. Soybean grain yield with all tested herbicide programs did not differ and ranged from 1219 to 1477 kg ha^{-1} at Hays site. However, PRE fb POST programs increased soybean grain yield by 10% over the PRE only programs at Manhattan site. In conclusion, these results suggest that the PRE fb POST (two pass) herbicide programs (with multiple sites of actions) can be utilized for season-long control of GR Palmer amaranth in Roundup Ready 2 Xtend® soybean.

CANOPY STRUCTURE OF WHEAT VARIETIES AND THEIR INFLUENCE ON THE WEED SUPPRESSIVE ABILITY. M. E. Cena[1], H. A. Acciaresi*[2]; [1]CIC, Pergamino, Argentina, [2]Instituto Nacional Tecnologia Agropecuaria, Pergamino, Argentina (64)

ABSTRACT

The objective of the present study was to evaluate the influence of wheat morphological traits on their weed suppressive ability. The weed suppressive ability is the capacity of a crop plant to reduce weed growth through a greater resource's uptake. The experiments were carried out at the Pergamino Experimental Station of the National Institute of Agricultural Technology (33° S, 60° W, Argentina). Eight commercial varieties of wheat that present a differential structure, were used. In each experimental unit, morphological characteristics of wheat (height, length and width of the leaf blades, foliar insertion angle) and aboveground dry matter of weeds were evaluated at tillering (Z 2.9) and flowering (Z 6.5). There was significant variation in height, length and width of the leaf blades, foliar insertion angle and aboveground dry matter of weed. Aboveground dry matter correlated negatively with height and length of the leaf. The result show that height and leaf blades influence on the weed suppressive ability of wheat.

EFFECTS OF COVER CROP MIXTURES IN THE WEED EMERGENCE AND ABOVE GROUND DRY MATTER. M. V. Buratovich[1], H. A. Acciaresi*[2]; [1]Inta Pergamino, Pergamino, Argentina, [2]Instituto Nacional Tecnologia Agropecuaria, Pergamino, Argentina (65)

ABSTRACT

The objective of this study was to determine the effect of different cover crops (CC) on weed emergence and above ground dry matter. The species used as CC were oats (Avena sativa), triticale (Triticosecale) and vetch (Vicia villosa). These were sown in monocultures and double mixtures (oats/triticale, oats/vetch and triticale/vetch) and triple ones (oats/triticale/vetch), with 250 pl.m-2. A plot was left with no CC as a negative control. In each experimental unit, above ground dry matter of CC and weeds were measured in three moments: vegetative stage, reproductive and maturity of CC growing cycle. In vegetative stage of CC triticale/vetch and oats/triticale/vetch showed the highest above ground dry matter (485 kg.ha-1), while oats/triticale and vetch, the lowest one (275 kg.ha-1). Above ground dry matter and number of weeds showed significant differences in fallow with CC. In reproductive stage of CC, oats showed the highest above ground dry matter of weeds ($p<0.01$) and CC didn´t show significant differences in above ground dry matter. At CC maturity, oats/triticale, oats and triticale showed de highest number of weeds (32 pl.m-2) and above ground dry matter (10045 kg.ha-1). Fallow showed the highest above ground dry matter of weeds ($p<0.01$). The use of CC would reduce the number and above ground dry matter of winter and spring weeds in the productive systems of the region.

EFFECT OF FALLOW SEQUENTIAL SPRAY OF ALS HERBICIDES IN SOYBEAN GRAIN YIELD PRODUCTIVITY. M. A. Principiano*[1], H. A. Acciaresi[2]; [1]CIC-UNNOBA, Pergamino, Argentina, [2]Instituto Nacional Tecnologia Agropecuaria, Pergamino, Argentina (66)

ABSTRACT

The stacking of residual ALS herbicides in the soil by their continued and repeated use can increase the phytotoxicity problems in the rotation crops. In this context, it is important to determine how the sequential application of residual herbicides of the group of ALS inhibitors affects the behavior of agricultural sequence in the region, in order to rationalize their use and their environmental impact. The study consisted in a field study and another in controlled conditions by conducting bioassays. A phytotoxic effect of the ALS inhibiting herbicides on the length (mm) of the main root of soybean quantified was detected by experiments under controlled conditions (bioassays), whereas under field conditions no phytotoxic effect of residual ALS herbicides was evident.

INDUSTRIAL HEMP HERBICIDE TOLERANCE SCREENING. M. L. Flessner*, J. Byrd, J. Fike, K. W. Bamber; Virginia Tech, Blacksburg, VA (67)

ABSTRACT

Prohibition on industrial hemp (*Cannabis sativa* L.) production was recently lifted in the United States. While interest in a possible new cash crop is high, best management practices, including weed control, are not known. Therefore, research was conducted to evaluate herbicide tolerance of industrial hemp.

Field screening trials were established in conventional tillage in early June using 'Helena' in 2017 and 'Joey' in 2018, both monoecious, dual-purpose cultivars. All studies used a randomized complete block design with four replications per treatment with 6.7 m^2 plots, and all studies were repeated in time. Preemergence (PRE) and postemergence (POST) studies were conducted separately. The PRE study was planted at 27 kg ha^{-1} with 19 cm row spacing while the while POST study was planting at 22 kg ha^{-1} with 38 cm row spacing. Both studies were weed free at planting. Treatments for the PRE study included fomesafen at 0.42 kg ha^{-1}, pendimethalin at 1.6 kg ha^{-1}, *S*-metolachlor at 1.6 kg ha^{-1}, linuron at 1.4 kg ha^{-1}, and chlorimuron at 35 g ha^{-1} applied within 2 days of planting. Treatments for the POST study included surfactants according to product labels and included quizalofop at 77 g ha^{-1}, sethoxydim at 315 g ha^{-1}, bromoxynil at 280 g ha^{-1}, halosulfuron at 53 g ha^{-1}, and clopyralid at 139 g ha^{-1} applied when hemp was ~25 cm tall. Both studies included a nontreated check. Data collected included visible injury (0 to 100% scale) and grain yield. Stand counts were also conducted in the PRE study.

S-metolachlor was the safest PRE herbicide, resulting in 0 and ≤15% injury in 2017 and 2018, respectively, and a stand count that was 97% of the nontreated (pooled across years). Fomesafen resulted in 8 to 25% injury across rating timings and years and 76% stand count relative to the nontreated. Other PRE treatments resulted in >50% injury in at least one year. Chlorimuron and pendimethalin reduced stand counts to 61 and 32% of the nontreated. Despite injury and stand count reductions, no yield differences were observed due to PRE herbicides; 364 and 672 kg ha^{-1} grain yield resulted in the nontreated in 2017 and 2018, respectively. POST herbicides sethoxydim, quizalofop, bromoxynil, and clopyralid all resulted in <20% injury across ratings and years and similar grain yield as the nontreated (588 kg ha^{-1}). Halosulfuron resulted in ~60% injury and reduced grain yield to 397 kg ha^{-1}. Overall, results indicate that *S*-metolachlor applied PRE or sethoxydim, quizalofop, bromoxynil, and clopyralid applied POST are suitable for industrial hemp production, but some of these treatments caused transient visible injury. Future research should be conducted to corroborate results across cultivars, soil types (for PRE treatments), and environments.

PERSPECTIVES ON WHEAT YIELD LOSSES DUE TO WEEDS IN NORTH AMERICA. M. L. Flessner*[1], A. Dille[2], P. Sikkema[3], I. C. Burke[4], W. Everman[5], M. J. VanGessel[6]; [1]Virginia Tech, Blacksburg, VA, [2]Kansas State University, Manhattan, KS, [3]University of Guelph, Ridgetown, ON, [4]Washington State University, Pullman, WA, [5]North Carolina State University, Raleigh, NC, [6]University of Delaware, Georgetown, DE (68)

ABSTRACT

Yield losses due to weeds are a major threat to wheat production and economic well-being of farmers. Canada and the United States (US) account for 4.0 and 8.9% of the world's wheat production (670.5 metric tons or 2.46 billion bu), respectively. The objective herein is to report potential wheat yield and economic losses due to weeds in the US and Canada. Requests for data were sent to weed scientists in 2013 and 2014. Each scientist was asked to report average yield of both weedy (best management practices but no weed control) and weed-free (best management practices and excellent (>95%) weed control) within replicated research plots in both winter and spring wheat. Scientists could report up to 10 studies per year for the period of 2007 to 2013. Yield loss (%) was determined for each study, then averaged within a year, and then averaged across years for each state or province. State and province data for acres harvested, average yield, and total production by year for both winter and spring wheat were collected from USDA-NASS and Statistics Canada. Average commodity price data (US$ 208.71/metric ton or 5.68/bu and US$ 234.43/metric ton or 6.38/bu for winter and spring wheat, respectively) were obtained from USDA-NASS for the 2007 to 2013 period and used to estimate economic loss. Data were received from states and provinces that represented 49, 63, and 48% of US, Canadian, and total winter wheat production, respectively, and 46% of US spring wheat production (insufficient data received for Canadian spring wheat production). Winter wheat yield loss estimates ranged from 2.9% (Lake States) to 31.4% (Northern Plains), with a weighted average (by production) of 24.5% for the US, 2.9% for Ontario, and 22.4% for North America. Based on these yield loss estimates and total US and Canadian production, potential winter wheat loss due to weeds is 10.4, 0.4, and 10.1 million metric tons (385.5, 15.3, and 400.8 million bu) with a potential loss in value of US$ 2.19, 0.87, and 2.28 billion for the US, Canada, and total, respectively. US spring wheat yield loss estimates ranged from 32.6% (Mountain States) to 47.0% (Lake States), with a weighted average (by production) of 35.3%. Based on this yield loss estimate and total production, potential US spring wheat loss is 5.1 million metric tons (189 million bu) with a potential loss in value of US$ 1.21 billion.

HERBICIDE RESISTANCE IN MONTANA: CURRENT STATUS AND FUTURE DIRECTIONS. P. Jha*[1], V. Kumar[2], C. A. Lim[1], R. Yadav[1], S. Leland[1], J. Anjani[1]; [1]Montana State University, Huntley, MT, [2]Kansas State University, Hays, KS (69)

ABSTRACT

Herbicide-resistant (HR) weeds are an increasing concern for Montana producers. Increasing HR populations of kochia, Russian thistle, wild oat, and Persian darnel are evident in Montana farm fields. Wild oat resistance to multiple modes of action including ACCase- and ALS-inhibitor herbicides is widespread in predominantly cereal-based cropping systems of Montana. Downy brome with cross resistance to ALS inhibitors used in winter wheat has been recently documented in the state. The evolution of glyphosate-resistant kochia (first weed to develop glyphosate resistance in Montana) and presence of auxinic (dicamba and fluroxypyr)- and ALS-inhibitor-resistant kochia is a potential threat to Montana dryland cropping systems. Glyphosate and ALS-inhibitor (multiple-resistant) kochia biotypes were first found in chemical fallow (wheat-fallow rotation) fields in northern Montana (2012/2013) and now widespread across several Counties. Glyphosate-resistant Russian thistle is another concern for cereal producers in the state. Fall-applied soil residual herbicides (multiple modes of action) is currently recommended in wheat-fallow or wheat-pulse rotations to manage resistant kochia and Russian thistle seed banks. Recent spread of glyhosate-resistant kochia in irrigated sugar beet growing areas of the state is a potential threat to the sustainability of glyphosate-resistant (Roundup Ready®) sugar beet production. Multiple resistance to dicamba and glyphosate further limits options for kochia control in corn-sugar beet rotations. Therefore, it is crucial for sugar beet growers to better manage the resistant weed seed bank in crops (wheat/barley: more effective alternative modes of action available) grown in rotation with glyphosate-resistant sugar beet. The ideal strategy for mitigating HR kochia should embrace a "zero-seed threshold" approach at a cropping-systems level. Therefore, the long-term herbicide-resistance management programs should encourage the use of more diversified crop rotations, tillage, cover crops, and harvest weed seed control (HWSC). This widespread occurrence of multiple HR weeds in MT and the Great Plains region has renewed research efforts to devise integrated weed management (IWM) strategies beyond herbicide use. Remote sensing and site-specific weed management using automated, sensor-based technologies hold promise.

THE INFLUENCE OF APPLICATION TIMING ON SEQUENTIAL APPLICATIONS OF ENLIST DUO, ENLIST ONE, AND LIBERTY ON PALMER AMARANTH CONTROL. D. C. Foster*[1], P. A. Dotray[1], K. R. Russell[1], M. Lovelace[2]; [1]Texas Tech University, Lubbock, TX, [2]Corteva Agriscience, Lubbock, TX (70)

ABSTRACT

The southern United States produces approximately 90% of the U.S. cotton (Webster 2012), with the Texas High Plains region being the largest contiguous cotton producing region. Since 2011, glyphosate resistant Palmer amaranth has threatened Texas cotton production, making it critical for producers to begin looking for alternatives to systems that previously had a heavy reliance on glyphosate. Previous research has shown that sequential applications of 2,4-D, 2,4-D + glyphosate, and glufosinate controlled Palmer amaranth >80% when applied to 7 cm weeds (Merchant et al. 2014). In 2018, a field experiment was conducted in a non-crop area in Lubbock, Texas to determine the efficacy of 2,4-D choline + glyphosate (Enlist Duo), 2,4-D choline (Enlist One), and glufosinate (Liberty 280 SL) on Palmer amaranth when applied at different weed heights and different sequential order. The population of glyphosate resistant Palmer amaranth was approximately 20% at this site with a population density of >215 plants per square meter. When applications were initiated at 7 to 15 cm weeds, Enlist Duo and Liberty were more effective than Enlist One at controlling Palmer amaranth when evaluated 10 days after the initial sequential application. At 10 days after the sequential application, all combinations of Enlist Duo, Liberty, and Enlist One controlled 7 to 15 cm Palmer amaranth >92% except Enlist Duo followed by (fb) Enlist One and Enlist One fb Enlist One. Weeds 7 to 15 cm in height were controlled 90-97% by Enlist Duo fb Enlist Duo or Liberty, Enlist One fb Enlist Duo, and Liberty fb Enlist Duo at 21 days after the sequential application. Enlist Duo was more effective than Liberty and Enlist One at controlling 25 to 30 cm Palmer amaranth when evaluated 10 days after the initial sequential application. Only Enlist Duo fb Enlist Duo or Liberty and Liberty fb Enlist Duo controlled Palmer amaranth >95% at 10 days after the sequential application when applied to 25 to 30 cm weeds. At 21 days after the sequential application, Enlist Duo fb Enlist Duo, Liberty, or Enlist One were the only sequential combinations to control 25 to 30 cm Palmer amaranth 91-98%. Regardless of weed size, Enlist Duo and Liberty in either sequential order was effective at controlling Palmer amaranth. These two modes of action systems would be a suitable best management practice for herbicide resistant weed management when used in conjunction with soil residual herbicides.

HYPERSPECTRAL REFLECTANCE PROPERTIES OF REDROOT PIGWEED VERSUS OKRA LEAF COTTON. R. Fletcher*; USDA-ARS, Greenville, MS (71)

ABSTRACT

SYSTEMS APPROACH TO WEED MANAGEMENT IN CORN IN WISCONSIN. R. Werle*[1], R. P. Dewerff[2], S. V. Striegel[3], N. Arsenijevic[1], V. H. Vidal Ribeiro[1], M. Coura Oliveira[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]Agricultural Research of Wisconsin, LLC, Madison, WI, [3], What Cheer, IA (72)

ABSTRACT

A recent Wisconsin Cropping Systems survey found the majority of respondents utilize a 1-pass herbicide program in corn production. Additionally, >70% of respondents complete a form of tillage on their operation, predominantly field cultivation prior to planting. As the number of resistant weed populations increases and the natural shifts in weed species composition becomes more challenging to control with a 1-pass system, more growers are interested in rotating to different effective sites of action (SOA) and/or adopting a 2-pass system. Concerns regarding this shift are largely economic; however, the risk of competition between weed and crop species contributing to yield loss and greater weed seed bank depositions may not be worth upfront reduced input costs. A field study was conducted in 2018 in Arlington and Janesville, WI to determine the season-long efficacy of different system approaches containing multiple effective herbicide SOA from three collaborating companies. The study consisted of 12 treatments, plus an untreated check, comparing four approaches: 1-pass PRE, 1-pass Early POST (at V2 growth stage), 2-pass PRE fb POST (at V4 corn growth stage), and 2-pass PRE fb POST + residual (at V4 corn growth stage); treatments were replicated four times and organized in RCBD. End of season overall weed control ratings (%) and biomass (g m^{-1}) were recorded. All treatments provided satisfactory weed control in Arlington. However, in Janesville, 2-pass program treatments provided the best weed control; when comparing the 1-pass systems, an Early POST program resulted in better weed control than a PRE-only program. The weed spectrum present at the Janesville location (heavy infestation of *Ambrosia trifida*) is more difficult to control in comparison to the Arlington location (*Chenopodium album* and *Poaceae* species), thus, explaining the weed control differences between sites. Biomass measurements correlated well with weed control ratings for both sites. Weed control across company portfolios was comparable. There was no significant yield difference between the 1-pass Early POST compared to the 2-pass programs. The 2-pass program treatments enhanced nearly complete weed control, reducing weed seed depositions in the seed bank that could have persisted and impacted crops in future growing seasons. This study will be replicated in the 2019 growing season.

DOES OVERLAP OF PROVISIA HERBICIDE IMPACT ACCASE-RESISTANT RICE TOLERANCE? B. McKnight*[1], E. P. Webster[1], S. Rustom[1], C. Webster[2], D. C. Walker[1]; [1]Louisiana State University, Baton Rouge, LA, [2]Louisiana State University, Baton Rouge, AL (73)

ABSTRACT

Weedy rice is a complex of red rice, red rice outcrosses, and F_2 hybrids that infests some Louisiana rice fields. Management of weedy rice that is resistant to the imidazolinone herbicides is especially difficult. Provisia is a new herbicide technology from BASF and was first commercially available in 2018. Provisia is the herbicide and the resistant rice lines. Provisia herbicide is quizalofop, an ACCase inhibiting herbicide that controls annual and perennial grasses. BASF developed Provisia as a management tool for imidazolinone-resistant weedy rice infestations in cooperation with the LSU AgCenter, which is developing the Provisia rice lines. Currently, only one Provisia variety, 'PVL01', is available to growers. In 2018, field studies were conducted at the H. Rouse Caffey Rice Research Station near Crowley, Louisiana. The objective of this research is to evaluate quizalofop injury on 'PVL01' rice following two consecutive applications of quizalofop at labeled rates to simulate an application overlap.

Following seedbed preparation, 'PVL01' rice was drill-seeded at 67 kg ha^{-1} on 19-cm rows. Experimental design was a randomized complete block design with four replications and plot size was 1.5 by 5.1 m^2. Pendimethalin and quinclorac was applied DPRE across all plots for weed control at 1120 and 420 g ai ha^{-1}, respectively. Provisia herbicide was applied in a sequential program at 100 fb 138, 120 fb 120, and 138 fb 100 g ai ha^{-1}, and in a single application at 240 g ai ha^{-1}. In sequential programs the first treatment was applied to 2- to 3-leaf rice fb treatments applied to 4- to 5-leaf rice. Treatments of 240 g ai ha^{-1} were applied at either the 2- to 3-leaf or the 4- to 5-leaf growth stage and represented the maximum labeled rate of Provisia in a single application. Within each of the programs, one treatment was applied in a single pass and two separate treatments were overlapped by a consecutive pass at either the 2- to 3-leaf or 4- to 5-leaf growth stage to simulate an application overlap at those timings. 'PVL01' injury from Provisia herbicide was evaluated at 14 DA 2- to 3-leaf applications and 14 DA 4- to 5-leaf applications. Rice plant height was recorded at 14 DA 2- to 3-leaf applications, 28 DA 4- to 5-leaf applications, and immediately prior to harvest. Rice grain was harvested with a small plot combine and final rough rice grain weight was adjusted to 12 % moisture.

At 14 DA 2- to 3-leaf applications visual injury was 16 to 40% on rice not treated with a Provisia overlap. Injury was 41 to 70% on rice treated with an overlap application of Provisia herbicide. The most severe visual injury observed, 70%, was on rice treated with an overlap of 240 g ai ha^{-1}. At 14 DA 4- to 5-leaf applications, injury of rice treated with a single pass of any Provisia rate had dissipated. Injury of rice treated with an overlap application at the 2- to 3-leaf timing was 6 to 21%, indicating recovery from herbicide injury was occurring. Rice treated at the 4- to 5-leaf application timing was injured 6 to 23% at 14 DA 4- to 5-leaf applications. At 14 DA 2- to 3-leaf applications, rice treated with an overlap rate of 240 g ai ha^{-1} was shorter than rice receiving any other rate. By the last height evaluation, immediately prior to harvest, no differences in rice plant height was observed from any herbicide treatment.

KOCHIA (*BASSIA SCOPARIA*) CONTROL AND ENLIST COTTON (*GOSSYPIUM HIRSUTUM*) RESPONSE FOLLOWING PREPLANT HERBICIDE TREATMENTS. U. Torres*[1], P. A. Dotray[1], K. R. Russell[1], G. K. Flusche Ogden[1], M. Lovelace[2]; [1]Texas Tech University, Lubbock, TX, [2]Corteva Agriscience, Lubbock, TX (74)

ABSTRACT

Kochia (*Bassia scoparia L.*) is an introduced annual weed commonly found throughout the western and northern United States. It is native to central and eastern Europe and Asia. Kochia grows well in low rainfall, high salinity, and arid to semi-arid regions. In the Texas Southern High Plains, kochia is difficult to control if not properly managed early in the growing season. There also are reports that some areas may contain herbicide-resistant populations, which will add to the complexity of control. In Texas, kochia populations were found to contain resistance to metsulfuron-methyl, an ALS inhibitor. With the introduction of the Enlist™ technology system by Corteva Agriscience™ , growers have more options to control troublesome weeds preplant and in-season. The objective of this study was to evaluate preplant herbicide treatments for control of kochia in an Enlist™ system. The study was conducted at the Texas A&M AgriLife Research and Extension Center in Lubbock, TX. Seven treatments (flumioxazin (Valor® SX) at 0.077 kg ai/ha plus 2,4-D amine at 1.2 kg ai/ha; rimsulfuron at 0.018 kg ai/ha plus thifensulfuron at 0.018 kg ai/ha (LeadOff®) plus 2,4-D amine; fluroxypr (Starane® Ultra) at 0.17 kg ai/ha plus 2,4-D amine; flumioxazin plus glyphosate (Roundup PowerMAX®) at 1.7 kg ae/ha; rimsulfuron and thifensulfuron plus glyphosate; fluroxypr plus glyphosate; and dicamba (FeXapan™) at 0.61 kg ae/ha plus glyphosate) were applied with a CO_2 pressurized backpack sprayer 45, 30 and 15 days before planting. Kochia was controlled ≥92% at planting following all 45 and 30 DBP treatments except flumioxazin plus glyphosate. Only dicamba plus glyphosate controlled kochia ≥90% at planting when applied 15 days before planting. Dicamba plus glyphosate injured cotton (delayed emergence, reduced stand, plant stunt, visual phytotoxicity), which was not surprising since the planted technology was Enlist™ cotton and this treatment was included for efficacy comparisons only. No other treatment caused cotton injury. Blanket in-season treatments included 2,4-D choline plus glyphosate (Enlist Duo®) early-postemergence, cultivation, and diuron postemergence-directed to control kochia and other weeds in-season. No differences in lint yield were observed following any preplant treatments.

MANAGEMENT OF *BROMUS* SPECIES WITH PYROXASULFONE AND METRIBUZIN IN WINTER WHEAT. R. J. Zuger*, I. C. Burke; Washington State University, Pullman, WA (75)

ABSTRACT

Alternative herbicide modes of action to acetolactate synthase (ALS) inhibitors for downy brome (*Bromus tectorum* .L.) management in the dryland wheat-fallow systems of the Pacific Northwest (PNW) are under evaluation due to increasing grower concerns of ALS inhibitor resistance in downy brome. Herbicides that inhibit ALS are the primary herbicide option for downy brome control in wheat. Sterile brome (*Bromus sterilis* L.) was recently identified bromegrass invading wheat fields in intermediate and low rainfall zones of the PNW. Our objective was to identify one or more herbicides with different modes of action for management of downy brome and sterile brome. Three studies were established in winter wheat grown in areas that receive 20 to 30 cm of annual participation in 2017 or 2018. Treatments consisted of delayed preemergence (delayed-PRE) herbicides applied in the fall as the whole-plot and postemergence (POST) applications in the early spring arranged in a stripped-block design. Delayed-PRE treatments consisted of combinations of pyroxasulfone, metribuzin, and diclofop. Diclofop was not incorporated. Stripped-block POST treatments were propoxycarbazone, mesosulfuron, pyroxsulam, or imazamox (depending of wheat cultivar). Brome control was assessed by visual estimation and brome biomass was harvested from each split block in early summer. Data was subjected to an ANOVA and significant differences between treatments were analyzed using Fisher's protected LSD. In the 2017 study near Anatone, WA, pyroxasulfone (89 g ai ha^{-1}) in combination with metribuzin (420 g ai ha^{-1}) had the greatest reduction in brome biomass with 330 kg ha^{-1} compared to 2280 kg ha^{-1} for the nontreated. Metribuzin (420 g ai ha^{-1}) alone also reduced brome biomass (810 kg ha^{-1}). Yield was similar for delayed-PRE treatment in 2017. In 2018, similar results were observed with reduction in brome biomass for treatments of pyroxasulfone (89 g ai ha^{-1}) alone, pyroxasulfone (89 g ai ha^{-1}) with metribuzin (210 g ai ha^{-1}), pyroxasulfone (89 g ai ha^{-1}) with diclofop (1120 g ai ha^{-1}), and pyroxsulafone (89 g ai ha^{-1}) with both metribuzin (210 g ai ha^{-1}) and diclofop (1120 g ai ha^{-1}) together. Yield was positively impacted by all delayed-PRE treatment, except propoxycarbazone, at the Anatone, WA, site in 2018 compared to the nontreated control. At the Ewan, WA, site in 2018, the delayed-PRE treatments caused no affect on yield, however yield was numerically greater when brome biomass was reduced. In conclusion, pyroxasulfone alone and in combination with metribuzin or diclofop, when applied at the appropriate timing, could be an effective option for downy brome and sterile brome management in eastern Washington winter wheat.

STATE OF RESISTANCE FOR PALMER AMARANTH POPULATIONS FROM THE NORTH CAROLINA COASTAL PLAIN. D. J. Mahoney*[1], D. Jordan[2], A. T. Hare[2], N. R. Burgos[3], K. M. Jennings[2], R. Leon[2], M. C. Vann[2]; [1]North Carolina State University, Cary, NC, [2]North Carolina State University, Raleigh, NC, [3]University of Arkansas, Fayetteville, AR (76)

ABSTRACT

Palmer amaranth (*Amaranthus palmeri* S. Wats.) is one the most problematic weeds in the United States. It is a highly competitive weed with immense fecundity and has the ability to replenish the soil-seed bank in one generation. Palmer amaranth is an obligate cross-pollinator, possesses a high amount of genetic variation and its pollen has been shown to move significant distances. Along with immense herbicide selection pressure, these characteristics have led to Palmer amaranth populations resistant to several mechanisms of action (MOA) with some populations expressing multiple resistance. In North Carolina (NC), resistance to acetolactate synthase (ALS) and 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase inhibitors is widespread and suspicion of resistance to protoporphyrinogen oxidase (PPO) inhibitors within Palmer amaranth exists. Greenhouse research was completed to determine the presence and distribution of Palmer amaranth population from the NC Coastal Plain expressing possible resistance to multiple MOA. In fall 2016, 110 Palmer amaranth populations were collected from fields predominantly in the NC Coastal Plain, the state's primary peanut producing region. Following inflorescences being dried, threshed, and cleaned, seeds were sown into cellular trays thinned to one plant $cell^{-1}$. When plants reached the 2- to 4-leaf stage, they were treated with glufosinate (451 g ai ha^{-1}), glyphosate (840 g ae ha^{-1}), fomesafen (280 g ai ha^{-1}), mesotrione (105 g ai ha^{-1}) or thifensulfuron-methyl (17.5 g ai ha^{-1}) in separate experiments (two per herbicide). Plant injury was estimated visually (0 to 100%) and mortality was recorded 3 wks after application.

Only 4 populations had no survivors following application of thifensulfuron-methyl. Of the other populations with survivors (< 90% injury), 69 had survival frequencies of 1 – 30%, 35 with 31 – 70%, and the remaining 2 with 71 – 80%. Following glyphosate, only 1 population was completely controlled with 9 populations having survival frequencies in the 1 – 30% range. Higher survival frequencies were more common with glyphosate as 38 and 62 populations had survival frequencies of 31 – 70% and 71 – 100%, respectively. Survival following mesotrione was less frequent with 68 populations being completely controlled. While 41 populations had survival frequencies of 1 – 10%, 37 fell below 5% survival rate with the 1 population having 17% survival. Fomesafen controlled 106 of the populations completely with the remaining 4 falling in the 1 – 10% survival frequency. All populations were completely controlled following glufosinate application. In total, none of the tested populations were completely controlled by all herbicides and only 3 survived only one MOA. Within the other 107 populations, 65, 40, and 2 populations had survivors to 2, 3, and 4 MOA,

respectively. These data suggest that Palmer amaranth resistant to EPSP synthase and ALS inhibitors remains commonplace throughout the NC Coastal Plain. There is now greater cause for concern with populations which have individuals surviving PPO- and 4-hydroxyphenylpyruval dioxygenase inhibitors. While glufosinate currently remains active on these populations, extra caution should be taken to ensure proper application timing as decreased efficacy of this herbicide would be detrimental for many row crop systems in North Carolina.

CONTROL OF *AMARANTHUS PALMERI* WITH RESISTANCE TO INHIBITORS OF EPSPS AND ALS IN THE SUCCESSION OF SOYBEAN-COTTON. F. S. Ikeda*[1], S. D. Cavalieri[1], F. Poltronieri[2], A. Deon[2]; [1]Embrapa, Sinop, Brazil, [2]Federal University of Mato Grosso, Sinop, Brazil (77)

ABSTRACT

As a result of the potential problem that *Amaranthus palmeri* presents for Brazilian agriculture and because it has been identified as glyphosate and ALS inhibity herbicides resistant in the state of Mato Grosso, this study aimed to evaluate the application of herbicides in pre- and post- emergence in the soybean-cotton succession for the control of *A. palmeri*, aiming to provide alternatives of management of the species to the properties with their occurrence, as well as in the case of the species dissemination. The experimental design was a randomized complete block design with four replications and 14 treatments. The herbicide treatments (g ha^{-1}) were: two doses of pendimethalin (1,400 and 1,820) in pre-emergence (PRE) combined with fomesafen (250), lactofen (180), bentazon (600) and bentazon + imazamox] in post-emergence (POST) in soybean, followed by s-metolachlor (1,200) and trifluralin (1800) herbicides in PRE combined with two doses of ammonium glufosinate (400 and 600) in POST in cotton crop. The applications of pendimethalin (1,820) in PRE in soybean and cotton crops were also studied, followed by bentazon + imazamox [600 + 28] and ammonium-glufosinate (600) in POST in the respective crops, as well as the applications in PRE with pendimethalin (1,400) on soybean and s-metolachor (1,200) on cotton, pendimethalin (1,820) on soybean and trifluralin (1,800) on cotton and pendimethalin (1,820) on both crops. In addition, weeded and non-weeded controls were included. In the control percentage evaluation of *A. palmeri* at 7 and 14 days after the last application in soybean (DAA), satisfactory control (> 80%) was observed only for the application of pendimethalin in PRE with fomesafen or lactofen in post-emergency. In cotton crop, all combinations in pre- and post-emergence had a percentage of control greater than 95%. There was no effect of the treatments for plant height, the insertion height of the 1st. number of beaks per plant, stand and cotton yield, according to analysis of variance. It was concluded that the most recommended treatments for the control of *A. palmeri* in the soybean-cotton succession are those with the application of pendimethalin in pre and fomesafen or lactofen in post-emergence in soybean with s-metolachlor or trifluralin in pre and ammonium glufosinate in post-emergence in cotton crop.

RESPONSE OF PEANUT TO LOW RATES OF ENGENIA AT DIFFERENT GROWTH STAGES. T. Bararpour*[1], R. R. Hale[2], J. W. Seale[1]; [1]Mississippi State University, Stoneville, MS, [2]Mississippi State University, Fayetteville, AR (78)

ABSTRACT

Peanuts (*Arachis hypogaea*) are sensitive to dicamba. One of the greatest problems facing peanut producers in Mississippi is the off-target movement of dicamba to the sensitive crops such as peanuts. A field study was conducted in 2018 at the Delta Research and Extension Center, in Stoneville, Mississippi, to evaluate peanut response to low rates of Engenia (dicamba) at different growth stages of peanuts. Peanuts (Georgia-D6G) were planted on beds with 102-cm row spacing at a seeding rate of 26 seeds m^{-1} on May 7, 2018 and emerged on May 15. The study was designed as a 3 (peanut growth stage) by 3 (Engenia rates) factorial in a randomized complete block. Applications were made at three peanut growth stages: beginning bloom (June 18), beginning peg (July 5), and beginning pod (July 10). Engenia was applied at 1/16 X, 1/32 X (simulated drift rates), and Zero (no Engenia = check) rates of the labeled rate (1 X). All Engenia applications had NIS (non-ionic surfactant) at 0.25% (v/v). The labeled rate (1 X) of Engenia was 0.56 kg ai ha^{-1}.

Peanut injury was 8 and 5, 22 and 15, 20 and 13% for Engenia at 1/16 X; and 4 and 3, 15 and 11, 13 and 10% for Engenia at 1/32 X for beginning bloom, beginning peg, and beginning pod, at 11 and 13 weeks after emergence (WAE), respectively. Peanut height was reduced from 32 cm (nontreated check) to 29.6 and 30.3 cm from the application of Engenia at 1/16 X and 1/32 X at 9 WAE and from 44.5 cm (nontreated check) to 42 (Engenia 1/16 X) and 41.6 cm (Engenia 1/32 X) at 13 WAE, respectively (averaged over peanut growth stages). Peanut canopy width was 98.6 and 91.2, and 92.7 cm for the nontreated check, Engenia at 1/16 X, and Engenia at 1/32 X, respectively (averaged over peanut growth stages). Peanut yielded 3,998, 3,404, and 3,959 kg ha^{-1} from the application of Engenia at beginning bloom, beginning peg, and beginning pod stages, respectively (averaged over Engenia rates). Peanut yield was 4,139, 3,480, and 3,741 kg ha^{-1} for nontreated check, Engenia at 1/16 X and 1/32 X, respectively (averaged over peanut growth stages). Overall, simulated drift rates of Engenia at 1/16 X and 1/32 X reduced peanut yield 15.9 and 9.6%, respectively (averaged over peanut growth stages). The level of peanut injury in terms of growth stage and yield were as follows: beginning peg > beginning pod > beginning bloom.

THE SUSCEPTIBILITY OF SOYBEAN (*GLYCINE MAX*) TO SOIL INCORPORATED PALMER AMARANTH (*AMARANTHUS PALMERI*) AND PITTED MORNING GLORY (*IPOMOEA LACUNOSA*) RESIDUES. D. D. Joseph*; Clemson University, Clemson, SC (79)

ABSTRACT

Recently, reduced-till and no-till soybean (*Glycine max*) production are becoming more popular. As these practices become more widespread, more crop and weed residues are being introduced into the soil. To investigate the effects of this residue on crop growth, a study was conducted in the greenhouse to determine the effects of no-till soybean field production by separately introducing varying concentrations of Palmer amaranth (*Amaranthus palmeri*) and pitted morningglory (*Ipomoea lacunosa*) plant residues (aboveground portion of the plant) to soil. The study was arranged in a completely randomized experimental design with 5 treatments (including a control) and 5 replications. Treatments consisted of Palmer amaranth residues and pitted morningglory residues that were each incorporated into soil in concentrations of 20000, 40000, 80000 and 160000 ppm. A soybean seed was sown in each pot corresponding to each soil-residue treatment and the soybean plants were allowed to grow for 8 weeks before harvesting. Soybean dry weight, leaf area and leaf tissue nutrient content were recorded during the study. There was an overall decrease in soybean dry weight and leaf area as Palmer amaranth residue increased in the soil. In trial 1, Palmer amaranth residues of 160000 ppm and 80000 ppm in the soil significantly reduced soybean dry weight by 53% and 38% respectively. In trial 2, Palmer amaranth residues of 160000 ppm and 80000 ppm significantly reduced soybean leaf area by 97% and 94% respectively. In addition, there were slight visual differences in soybean plants grown in soils containing pitted morningglory residues; however, those differences weren't statistically significant. The results of this study demonstrated the allelopathic potential of Palmer amaranth residues and the susceptibility of soybean to the allelochemicals present in those residues. An increase in Palmer amaranth residue in soil was shown to reduce soybean growth and development and may ultimately reduce soybean yields.

CONTROL OF GLYPHOSATE-RESISTANT COMMON RAGWEED IN CORN WITH PREEMERGENCE AND POSTEMERGENCE HERBICIDES. N. Soltani*, L. R. Brown, P. Sikkema; University of Guelph, Ridgetown, ON (80)

ABSTRACT

A total of eight field experiments [4 with preemergence (PRE) and 4 with postemergence (POST) herbicides] were conducted during 2016 and 2017 to evaluate the efficacy of PRE and POST herbicides to control of glyphosate-resistant (GR) common ragweed in corn. Dicamba, dicamba/atrazine, mesotrione+atrazine, isoxaflutole+atrazine, saflufenacil/dimethenamid-P and S-metolachlor/mesotrione/bicyclopyrone/atrazine were the most efficacious herbicides among PRE herbicides evaluated, providing 94-100% control of GR common ragweed and reducing density and biomass 98-100%. Among POST herbicides, dicamba, dicamba/diflufenzopyr, dicamba/atrazine, topramezone + atrazine, bromoxynil + atrazine, glufosinate and 2,4-D ester provided 58 to 85% control at 4 WAA and 49 to 88% control at 8 WAA. Other POST herbicides evaluated controlled GR common ragweed 9 to 41%. Common ragweed density was reduced 97, 95, 95 and 87% and shoot dry weight was reduced 93, 95, 94 and 90% with bromoxynil + atrazine, dicamba, glufosinate and topramezone + atrazine applied POST in GR corn, respectively. Results show that dicamba, bromoxynil + atrazine, topramezone + atrazine and glufosinate are the most efficacious herbicides among POST herbicides evaluated for the control of GR common ragweed in GR corn.

POTENTIAL YIELD LOSS IN CORN, SOYBEAN, DRY BEAN AND SUGAR BEET DUE TO WEED INTERFERENCE IN NORTH AMERICA. N. Soltani*[1], A. Dille[2], T. J. Peters[3], I. C. Burke[4], W. Everman[5], M. J. VanGessel[6], V. Davis[7], P. Sikkema[1]; [1]University of Guelph, Ridgetown, ON, [2]Kansas State University, Manhattan, KS, [3]North Dakota State University, Fargo, ND, [4]Washington State University, Pullman, WA, [5]North Carolina State University, Raleigh, NC, [6]University of Delaware, Georgetown, DE, [7]BASF, Verona, WI (81)

ABSTRACT

The objective of this WSSA Weed Loss Committee report is to provide quantitative data on the potential yield loss in corn, soybean, dry bean and sugar beet due to weed interference in the United States and Canada. Researchers and extension specialists who conducted research on weed control in these crops provided data from their region. Specifically, data were requested from weed control studies in corn, soybean, dry bean and sugar beet, from up to 10 individual studies per calendar year over a number of years. Averaged across 2007 to 2013, weed interference in corn in the United States and Canada caused an average of 50% yield loss which equates to a loss of 142 million tonnes of corn valued at over US$28 billion annually. Averaged across 2007 to 2013, weed interference in soybean caused a 52% yield loss which equates to a loss of US$16.2 billion in the US and US$1.0 billion in Canada annually if no weed management tactics were employed. Averaged across 2007 to 2016, weed interference in dry bean in the United States and Canada caused an average of 71% yield loss which equates to annual loss of US$622 million in the United States and US$100 million in Canada. Averaged across 2002 to 2017, the average yield loss due to weed interference for the primary sugar beet growing areas of North America was estimated to be 70%. Thus growers in the US would lose approximately US$1.25 billion and growers in Canada would lose approximately US$25 million if weeds are not controlled. These results highlight the importance of continued weed science research for sustaining high crop yield and profitability of corn, soybean, dry bean and sugar beet production in North America.

GRAPE HYACINTH CONTROL IN A WHEAT-SOYBEAN ROTATION. S. C. Beam*[1], M. L. Flessner[2], M. J. VanGessel[3], K. Vollmer[3]; [1]Virginia Tech, Concord, NC, [2]Virginia Tech, Blacksburg, VA, [3]University of Delaware, Georgetown, DE (82)

ABSTRACT

Grape hyacinth is a perennial bulbous species in the Liliaceae family. It is commonly grown as an ornamental plant but it can spread into agricultural fields and become weedy. Grape hyacinth emerges in the fall, flowers in the spring and then dies back and goes dormant. Due to this lifecycle, the presence of grape hyacinth foliage in the fall can interfere with soybean harvest and wheat planting. There has been limited research on controlling grape hyacinth in cropping systems. Field research studies (fall applied and spring applied, respectively) were conducted to determine grape hyacinth control with herbicides available for use in wheat and prior to soybean planting. Fall applied herbicides consisted of paraquat (560 g ai ha^{-1}), carfentrazone (35 g ai ha^{-1}), glyphosate (1260 g ae ha^{-1}), dicamba (1120 g ae ha^{-1}), glyphosate + dicamba, three rates of metsulfuron (4.2, 8.4, 16.8 g ai ha^{-1}), metsulfuron (8.4 g ai ha^{-1}) + paraquat, sulfosulfuron (35.2 g ai ha^{-1}), and metsulfuron + chlorsulfuron (3.5 + 17.5 g ai ha^{-1}). Data collected in the fall applied experiment included visible control of grape hyacinth assessed on a 0 (no control) to 100 (complete control) scale, and soybean yield. Among fall applied herbicides, paraquat resulted in the greatest initial grape hyacinth control (90 to 100%). Long-term grape hyacinth, 16 months after application (MAA), was variable but the top performing treatments were glyphosate and metsulfuron + paraquat resulting in 65 and 50% control, respectively. Spring applied herbicides included paraquat, carfentrazone, glyphosate, dicamba, glyphosate + dicamba, metsulfuron (8.4 g ai ha^{-1}), sulfosulfuron, sulfosulfuron + paraquat, metsulfuron + chlorsulfuron, pyrasulfotole + bromoxynil (41 + 230 g ai ha^{-1}), and halauxifen + florasulam (5.5 + 5.3 g ai ha^{-1}). Data collected included visible control of grape hyacinth, grape hyacinth bulb number and biomass, and soybean yield. Following spring applications, grape hyacinth control in November (7 MAA) was variable but top performing treatments were glyphosate and metsulfuron, which resulted in at least 26% control. Grape hyacinth bulb counts followed spring applications of paraquat, carfentrazone, metsulfuron, and sulfosulfuron resulted in 73, 68, 69, and 60% reductions compared to the nontreated check. Despite product label prohibitions on rotation to soybeans, no soybean yield reductions were observed from any treatment in either study. Single applications of certain herbicides in the fall or spring of the year can result in good control (>80%) of grape hyacinth initially but long-term control is variable. Those products that provided the best initial control did not always provide the highest control in subsequent seasons, so farmers will need to determine herbicide selection based on their goals. Future research on controlling grape hyacinth could include sequential applications of herbicides as well as evaluating the effectiveness of tillage.

COMPARISON OF VARIOUS WATER AND TANK CLEANER RINSE SEQUENCES FOR EFFECTIVE REMOVAL OF DICAMBA FROM CONTAMINATED SPRAYER SYSTEMS. Z. A. Carpenter*, D. B. Reynolds, A. B. Johnson; Mississippi State University, Mississippi State, MS (83)

ABSTRACT

While the release of dicamba tolerant soybeans will aid growers in weed control, it will also present several challenges. Glyphosate is water soluble, allowing it to be easily removed from spray tanks through three rinses with water alone. Synthetic auxin herbicides however, are not as water soluble and therefore can be difficult to completely remove from sprayer components. Synthetic auxins are also highly active on some plant species at very low concentrations. The objective of this study was to determine if the use of multiple rinses utilizing a tank cleaner resulted in more complete removal of dicamba from contaminated sprayer systems compared to the standard water-cleaner-water procedure. Field experiments were conducted in 2017 and 2018 in Brooksville and Starkville, MS. A small-scale sprayer was designed to replicate the

cleanout procedures used on commercial sprayers. The system was first contaminated with dicamba (Xtendimax) at 560 kg ae ha^{-1} and rhodamine WT dye at 0.2% v/v. Following contamination, a three-rinse cleanout was conducted, with treatments consisting of each possible combination of cleaner (C) (Wipeout, Helena) and water (W) rinses. During each rinse, the solution was recirculated through the system for 15 minutes and samples were collected for both field and lab analysis. Once the sprayer was cleaned using the triple rinse procedure it was filled with an 867 g ae ha^{-1} rate of glyphosate (Roundup Powermax), and another sample was collected. All samples were sprayed over actively growing non-dicamba tolerant soybeans (*Glycine max* L.) at the R1 growth stage. Visual ratings for phytotoxicity were taken 7, 14, 21, and 28 DAT and plant heights were taken 14, 21, and 28 DAT. Samples collected during each rinse were analyzed using HPLC to determine auxin herbicide concentrations as a means to evaluate cleanout efficacy. Plants were harvested at the end of the growing season for yield. All data were analyzed in SAS 9.4 using the PROC GLIMMIX procedure. Means were separated using Fisher's Protected LSD at α=0.05. Data reveal that no differences exist among cleanout sequences in terms of visual plant injury, percent height reduction and percent yield reduction at 28 days after treatment (DAT) relative to the untreated check. At the glyphosate rinse timing all sequences yielded less than 13% visual injury and were not different than the untreated check. During the first rinse plant height reductions average 35% across all sequences. Following the first rinse no differences in plant height reduction exist among sequences compared to the untreated check. Yield reductions at the glyphosate rinse were less than 11%, and no differences were present among sequences and the untreated check. HPLC analysis show a reduction in dicamba concentration following each rinse, and by the third rinse all samples had less than 1 part per million (PPM) dicamba remaining, with no differences among sequences. Results from this study indicate that addition of multiple cleaner rinses does not improve cleanout efficacy, and that a three rinse cleanout utilizing only water rinses performed as well as all other sequences containing commercial tank cleaners.

CUTLEAF EVENING PRIMROSE (*OENOTHERA LACINIATA*) AND WINTER ANNUAL BROADLEAF CONTROL IN WHEAT IN MISSISSIPPI AND OKLAHOMA. C. Ferguson*[1], M. Manuchehri[2], M. T. Wesley[3], L. H. Merritt[3], K. L. Broster[1], Z. R. Treadway[1], J. Childers[2]; [1]Mississippi State University, Mississippi State, MS, [2]Oklahoma State University, Stillwater, OK, [3]Mississippi State University, MS State, MS (84)

ABSTRACT

Cutleaf evening primrose (*Oenothera laciniata*) is a major weed problem of wheat in Mississippi and Oklahoma. Given the significance of broadleaf weed pressure on wheat yield, a two-year field study in Mississippi and Oklahoma was conducted to understand what treatment options provide the best control of winter annual broadleaf weeds in wheat. Two field sites in Mississippi (Newton and Brooksville) and one field site in Oklahoma (Perkins) were drilled with wheat using appropriate planting populations and varieties for each state in mid-October in 2018. Treatments selected for comparison included dicamba, 2,4-D, fluroxypyr + thifensulfuron methyl, chlorsulfuron + metsulfuron-methyl, halauxifen-methyl + florasulam, and multiple combinations of the above herbicides. Yields will be taken at the end of the season to better separate treatments from the study. Weed control was assessed at 7, 14, 28, and 56 days after application (DAA) for all three locations. Results showed that for the 28 DAA control ratings across all three locations, primrose and winter annual broadleaf control ranged from 91.25% to 12.5% of the treated plots. The best three performing treatments across location were chlorsulfuron + metsulfuron-methyl plus 2,4-D, halauxifen-methyl + florasulam plus chlorsulfuron + metsulfuron-methyl and chlorsulfuron + metsulfuron-methyl alone with across location ratings of 84.6%, 83.3% and 83% respectively. The three lowest performing treatments were dicamba, MCPA ester, and 2,4-D alone with ratings of 42%, 47.5%, and 55% respectively. Yields will be taken in the spring, which will give a more complete picture of the effect of winter annual broadleaf competition on wheat in Mississippi and Oklahoma. Initial results though show that when chlorsulfuron + metsulfuron-methyl is tank mixed with 2,4-D or halauxifen-methyl + florasulam, cutleaf evening primrose and other hard to control winter annual broadleaves can be achieved.

HERBICIDE CARRYOVER TO VARIOUS FALL PLANTED COVER CROP SPECIES. L. S. Rector*[1], M. L. Flessner[1], K. B. Pittman[1], S. C. Beam[2], K. W. Bamber[1]; [1]Virginia Tech, Blacksburg, VA, [2]Virginia Tech, Concord, NC (85)

ABSTRACT

Herbicide Carryover to Various Fall Planted Cover Crop Species. L.S. Rector, M.L. Flessner, K.B. Pittman, S.C. Beam, K.W. Bamber; Virginia Polytechnic Institute and State University, Blacksburg, Va.

Abstract

Higher cover crop biomass, which is achieved most effectively through an early planting date, is positively correlated with greater summer annual weed control. However, planting early increases the risk for herbicides used during the cash crop growing season to persist in the soil and reduce cover crop establishment. Research was conducted to evaluate the potential for various herbicides to carryover and injure common cover crops used in Virginia.

Studies were conducted in Blacksburg, Virginia on a Ross silt loam and Suffolk, Virginia on a Kenansville loamy sand in 2016 and 2017. A randomized split block design with 4 replications was utilized with herbicide as the main plot and cover crop species as the sub plot. Plots were 3 by 9.1 m and contained two rows each of 10 different cover crops drilled at 16.5 cm apart. Herbicides that are typically or must be applied before crop emergence (PRE) were applied on ~June 1st, and residual herbicides that can be applied after crop emergence (POST) were applied on ~July 1st. Treatments were applied to bare ground using a 4 nozzle 1.83 m hand boom. Cover crops were planted September 1st. Cover crop species were wheat, barley, cereal rye, oats, annual ryegrass, forage radish, Austrian winter pea, crimson clover, hairy vetch, and rapeseed. Treatments consisted of a nontreated control and 30 herbicides: 12 PRE herbicides and 18 POST herbicides. PRE treatments were atrazine, simazine, bicyclopyrone + mesotrione + *S*-metolachlor, pyroxasulfone, saflufenacil, isoxaflutole + thiencarbazone-methyl, linuron, metribuzin, sulfentrazone, flumioxazin, and fluometuron. POST treatments were mesotrione, acetochlor, *S*-metolachlor, dimethenamid-*P*, pendimethalin, clopyralid, primisulfuron-methyl, prosulfuron, topramezone, tembotrione, rimsulfuron, trifloxysulfuron, chlorimuron-ethyl, cloransulam-methyl, fomesafen, thifensulfuron-methyl, and imazethapyr. Cover crop visible injury was assessed by species 3 and 6 weeks after planting (WAP) on a 0 (no injury) to 100% (complete necrosis) scale. Cover crop biomass for 0.6 row meters was collected 6 WAP. Data were analyzed using JMP Pro 14 and subject to ANOVA. Due to a high amount of 0s in the visible injury ratings, preventing normality of the data, a 0, no injury, or 1, some injury, was assigned to all data points and generalized using a linear model with a binomial distribution and logit link to determine if there was a significant difference in treatments with injury and those without injury. Means for the visible injury were then separated using Tukey's $HSD_{(\alpha=0.1)}$. Means for cover crop biomass were separated using Dunnett's $Test_{(\alpha=0.1)}$ with the nontreated as the control group. Data is presented by location to capture the difference in soil type.

Crimson clover, forage radish, and canola showed the greatest visible injury among all cover crop species. Fomesafen at 0.4 kg ai ha^{-1} resulted in the greatest visible injury (24%), followed by trifloxysulfuron at 0.01 kg ai ha^{-1} (23%), on forage radish 3 WAP at Suffolk. Fomesafen (24%) was the only treatment that injured forage radish at

Suffolk in 2017 6 WAP, and fomesafen resulted in the highest injury at 58% on forage radish at Kentland in 2017 6 WAP. Atrazine at 2.2 kg ai ha^{-1} resulted in 20% injury on forage radish at Kentland in 2016 6 WAP. Mesotrione at 0.1 kg ai ha^{-1} (21%) and trifloxysulfuron (26%) resulted in greater than 20% injury on crimson clover at Suffolk 3 WAP. At Suffolk in 2017 6 WAP, trifloxysulfuron resulted in 30% injury on crimson clover. Prosulfuron at 0.03 kg ai ha^{-1} resulted in 21% injury on canola at Suffolk 3 WAP. There was no significant difference detected in cover crop biomass.

IMPACT OF REDUCED RATES OF ISOXAFLUTOLE ON SOYBEAN GROWTH AND YIELD. D. Miller*[1], D. O. Stephenson[2]; [1]Louisiana State University AgCenter, St. Joseph, LA, [2]Louisiana State University AgCenter, Alexandria, LA (86)

ABSTRACT

Crops grown in close proximity along with similar equipment utilized in multi-crop farming operations come with many potential challenges involving off-target movement of herbicides or sprayer contamination. These added concerns justify research identifying possible deleterious effects on crops such as soybean. Therefore field studies were conducted in 2018 at the Northeast Research Station near St. Joseph, La with the objective to evaluate potential negative impacts of reduced rates of isoxaflutole on soybean growth and yield. A four replication factorial arrangement of treatments was used and included herbicide application timing (Factor A: unifoliate; 2 trifoliate; or 4 trifoliate) and herbicide treatment (Factor B: no herbicide or isoxaflutole @ 1x (0.094 lb ai/A), 1/8x, or 1/16x). Treatments were applied at designated timings following planting of P54A54X soybean on 5/8. Parameter measurements included visual crop injury 7 and 14 d after application (DAT) (chlorosis and necrosis), crop height 14 and 28 DAT as well as prior to harvest, and yield.

At 7 DAT, at both the unifoliate and 2 trifoliate application timings, the 1x herbicide rate resulted in greatest injury of 75 and 65%, respectively. The 1/8 and 1/16x herbicide rates resulted in equivalent injury of 4 and 1% and 34 and 30% at these respective timings. At the 4 trifoliate application timing, all herbicide rates resulted in equivalent injury ranging from 19 to 28%. At 14 DAT, no visual injury was observed at the unifoliate and 4 trifoliate application timings. At the 2 trifoliate application timing, slight differences were noted among herbicide rates however injury did not exceed 5%.

Averaged across application timing, height at 14 and 28 DAT and late season was reduced 22, 26, and 22%, respectively, only at the 1x herbicide rate.

At the unifoliate application timing, yield was only reduced at the 1x herbicide rate (26%). At the 2 trifoliate application timing, yield was reduced 22 and 11% at the 1x and 1/16x herbicide rates, respectively. At the 4 trifoliate application timing, yield reduction was greatest at the 1x herbicide rate (54%) and significant at the 1/8x herbicide rate (14%).

SEASON LONG HERBICIDE PROGRAMS IN MISSISSIPPI PEANUT PRODUCTION. K. L. Broster*[1], J. Ferguson[1], T. A. Baughman[2], B. Zurweller[3], B. Rushing[4]; [1]Mississippi State University, Mississippi State, MS, [2]Oklahoma State University, Ardmore, OK, [3]Mississippi State University, Starkville, MS, [4]Mississippi State University, Newton, MS (87)

ABSTRACT

Season Long Herbicide Programs in Mississippi Peanut Production

Mississippi is an important producer of peanuts for the United States. In 2017 there were 17,400 hectares harvested in Mississippi (USDA NASS, 2018). Weed control in peanuts is crucial to maximize yield, by preventing interference and competition for nutrients, water, and light. Peanuts are a slow growing crop that relies on both pre-emergent (PRE) and post-emergent (POST) herbicides to reduce the effect of weeds. The objective of this study is to determine the most effective PRE and POST combination for weed control in peanut. A field study was conducted at Mississippi State University and Oklahoma State University using 5 PRE and 3 POST herbicide programs. The treatments were compared to a non-treated and weed free treatment to determine the effect of a season-long herbicide program on weed control and peanut yield. Weed control ratings were collected at 7, 14, 28, 42, and 56 days after POST. At harvest, yield data was collected to determine most effective combination for season long weed control. The data indicates that there is no statistical difference between PRE and POST combinations in terms of weed control or yield at the Mississippi location. However at the Oklahoma location, there is difference among PRE and POST treatments in terms of weed control and yield. This can be due to differences of environmental factors among locations.

INFLUENCE OF SIX HERBICIDES APPLIED TO SILAGE CORN ON FALL PLANTED RYE AND RADISH COVER CROP GROWTH IN SOUTH DAKOTA SOILS. S. Pridie*[1], G. Shaffer[2], S. Potthoff[1], S. A. Clay[1]; [1]South Dakota State University, Brookings, SD, [2]South Dakota State University, Aberdeen, SD (88)

ABSTRACT

Herbicide applications are often used for burndown and residual weed control. There has been increased interest in using cover crops due to the potential soil and production benefits. However, herbicide residuals in the soil may result in poor cover crop growth. This study examined the growth of radish (*Raphanus raphanistrum*) and cereal rye (*Secale cereale*) in soils collected in the fall but treated in the spring with six herbicides to determine if residuals would injure these cover crops. The herbicides were applied at recommended rates to silage corn (*Zea mays*) in mid-May to early June at South Dakota State University's Southeast (Beresford, silty clay loam soil) and Northern (Groton, silt loam soil) Research Farms. Soil samples from replicated plots (4) at both locations were collected from the 0- to 6-cm depth in mid-September. Sampling days after herbicide application were 102 d (Spirit application, Groton), 122 d (all Beresford applications) and 136 d (all other Groton treatments). From application to sampling, growing degree days ranged from 1096 to 1469 (base 10°C) and rainfall ranged from 236 to 443 mm. A greenhouse study was conducted with soils placed in conetainers and 4 seeds of radish or rye planted into each. A nontreated soil from each location was used as a negative control. Shoot and root growth were measured 35 d after planting with measurements compared to the control soil using a one-way paired t-test. Radish showed no injury with any of the herbicides. Several herbicides reduced ($p \leq 0.05$) rye shoot fresh weight, height, and root weight with some locational differences. In Beresford soil, shoot weight was reduced 59% by Warrant, whereas in the Groton soil Python, Warrant, and Spirit reduced fresh weights by 31%, 23%, and 27%, respectively. Rye shoot heights in Beresford soils were reduced by Parallel, Glory, Python, Warrant, and Acuron by 23%, 19%, 15%, 22%, and 15%, respectively. Rye total root weight was reduced by Parallel, Glory, Python, Warrant, and Acuron by 35%, 38%, 49%, 54%, and 35%, respectively, in Beresford and by Warrant (44%) in Groton. These data indicate that herbicide residuals may be present in high enough concentrations to result in cover crop injury. The type and amount of injury were dependent on soil type, cover crop species, herbicide applied, and seasonal climate conditions.

EARLY DEVELOPMENT OF HORSEWEED *(CONYZA CANADENSIS L.)*. W. Molin*, K. Parys, C. L. Beck; USDA-ARS, Stoneville, MS (89)

ABSTRACT

Horseweed (*Conyza canadensis* (L.) Cronq.) is a competitive weed species found in many crop production fields and fallow areas in the Mid-South. Horseweed produces millions of small, elongated seed, botanically defined as achenes, yet relative to the quantity of propagules produced, few seedlings survive to produce mature plants. The objective of this research was to describe the early stages of horseweed germination and development leading to plant establishment. Radical emergence began 18 to 24 hours after exposure to light and adequate moisture. Cotyledons acquired chlorophyll while still within the pericarp. After emerging cotyledons separated exposing the adaxial surface toward light. A dense ring of root hairs formed immediately behind the root apex and elongate to about 1 mm by 48 hours after germination. Light was required for maximal germination and was much reduced in the dark. Germination was highest when moisture was at or above field capacity. These results indicate that initial seedling development may be suppressed by lack of adequate moisture at the earliest stages resulting in sparse stand establishment.

EFFECT OF ASULAM ON FALL PANICUM SEED PRODUCTION. D. Odero*, R. Negrisoli; University of Florida, Belle Glade, FL (90)

ABSTRACT

Effect of Asulam on Fall Panicum Seed Production

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Fall panicum (*Panicum dichotomiflorum* Michx.) is the most troublesome annual grass weed associated with sugarcane production in Florida. In Florida, there is a small window for fall panicum control very early postemergence with combinations of atrazine or metribuzin with ametryn when it is less than 4 cm in height. Rescue treatment of fall panicum with asulam applied alone or in combination with trifloxysulfuron are often used on fall panicum 30 to 45 cm or more in height later in the season. Application of such rescue treatments coincide with fall panicum panicle initiation to seed-filling reproductive phases of development. Studies were conducted to evaluate the effect of asulam applied alone (2,800 and 3,740 g ai/ha) or in combination with trifloxysulfuron (15.8 g ai/ha) on fall panicum control and seed production. Herbicide treatments were applied at the booting, heading, anthesis, and seed-filling stages of fall panicum reproductive phases of development. At 28 days after treatment (DAT), fall panicum at the booting stage was controlled 93 to 98% with asulam alone (3,740 g ai/ha) or in combination with trifloxysulfuron compared to 38 to 56% control with the lower rate of asulam alone or in combination with trifloxysulfuron. Fall panicum control at the heading stage was controlled 90 to 96% with asulam in combination with trifloxysulfuron compared to 28 to 41% control with asulam alone. Similarly, asulam in combination with trifloxysulfuron provided better fall panicum control (88 to 91%) at anthesis compared to asulam alone (31 to 49%). No fall panicum control was observed with asulam alone or in combination with trifloxysulfuron at the seed-filling stage. Fall panicum produced seeds at all reproductive phases when asulam was applied alone with the exception of the higher rate applied at the booting stage (25% probability of seed production). Combination of asulam (3,740 g ai/ha) with trifloxysulfuron only inhibited seed formation at the booting and heading stages. The other combinations resulted in 25 to 100% probability of seed production. These results show that fall panicum seed production was only be inhibited when rescue treatments (asulam at 3,740 g ai/ha + trifloxysulfuron at 15.8 g ai/ha) were applied between booting and heading stages. More studies are ongoing to corroborate these results.

SAFLUFENACIL, HALAUXIFEN-METHYL, AND OTHER HERBICIDES FOR PREPLANT WEED CONTROL. W. C. Greene*[1], M. L. Flessner[2], K. B. Pittman[2], K. W. Bamber[2], L. S. Rector[2], S. C. Beam[3], C. W. Cahoon[4]; [1]Virginia Tech, Virginia Tech, VA, [2]Virginia Tech, Blacksburg, VA, [3]Virginia Tech, Concord, NC, [4]Virginia Tech, Painter, VA (91)

ABSTRACT

Effectively controlling weeds prior to planting is essential in reducing early season competition, and therefore assuring an acceptable crop stand. Field studies were conducted in 2018 to evaluate the efficacy of various herbicides applied alone, and herbicide mixtures on a range of winter annual weeds such as annual ryegrass (*Lolium rigidum*Gaudin), cutleaf evening-primrose (*Oenothera laciniata*Hill), Virginia pepperweed (*Lepidium virginicum*L.), purple deadnettle (*Lamium purpureum*L.), common chickweed (*Stellaria media* L.), and Persian speedwell (*Veronica persica*Poir.) Treatments were arranged in a randomized complete block design with four replications. Visible control data was taken two and four weeks after treatment (WAT) on a scale of 0 to 100%. All glyphosate containing treatments provided greater than 90% visible control of annual ryegrass at 4 WAT. Glufosinate provided the greatestcontrol of cutleaf evening-primrose (95%) among the single active ingredient treatments, while glufosinate plus glyphosate (100%) and 2,4-D plus paraquat (100%) provided the greatest control among tank mixtures. 2,4-D plus glyphosate and glyphosate plus glufosinate were the only treatments that provided greater than 90% control of Virginia pepperweed. Purple deadnettle was most effectively controlled with glyphosate containing treatments, including glyphosate plus halauxifen-methyl which resulted in 100% control. All herbicides except for 2,4-D, dicamba, halauxifen-methyl, and saflufenacil provided acceptable control of common chickweed. Persian speedwell was effectively controlled with all glyphosate containing treatments as well as halauxifen-methyl plus paraquat. Saflufenacil and halauxifen-methyl have been shown to effectively control weeds such as horseweed (*Conyza canadensis* L.) these data indicate that combinations with other herbicides, such as glyphosate, are necessary for preplant control of other weed species.

RESIDUAL ACTIVITY OF THIENCARBAZONE-METHYL WITH AND WITHOUT COMMON SOYBEAN HERBICIDES. Z. D. Lancaster*[1], J. K. Norsworthy[1], G. L. Priess[1], T. Barber[2]; [1]University of Arkansas, Fayetteville, AR, [2]University of Arkansas, Lonoke, AR (92)

ABSTRACT

Because of the continuous spread of herbicide resistance, growers are increasingly relying on residual herbicides to achieve effective weed control. New residual herbicide options are needed to effectively rotate herbicide sites of action and slow the development of additional herbicide resistance. Thiencarbazone-methyl (TCM), an acetolactate synthase-inhibiting herbicide, could provide preemergence and postemergence activity on many troublesome weeds in soybean. A field experiment was conducted at the Agricultural Research and Extension Center in Fayetteville, Arkansas in the summer of 2016 and 2017 to determine the residual activity of TCM compared to several common residual herbicides. The experiment was set up as a two factor, randomized complete block design with factor-A being TCM rate applied and factor-B being additive to the mixture. TCM treatments evaluated were TCM at 0, 33.5, and 67 g ha^{-1}. Additive herbicides to each rate of TCM were labeled rates of

S-metolachlor, flumioxazin, pyroxasulfone, metribuzin, and isoxaflutole. Data were collected on entireleaf morningglory (*Ipomoea hederacea*), broadleaf signalgrass (*Urochloa platyphylla*), and yellow nutsedge (*Cyperus esculentus*) control at 14, 28, 42, and 56 days after application (DAA) for both years with Palmer amaranth (*Amaranthus palmeri*) control evaluated in 2016. Overall, TCM provided excellent control of broadleaf signalgrass with 92% and 98%, respectively, for 33.5 and 67 g ha^{-1} at 42 DAA. Control of ALS-resistant Palmer amaranth was only 69% with 67 g ha^{-1} of TCM at 42 DAA in 2016. However, the addition of TCM at 67 g ha^{-1} to metribuzin resulted in an increase in Palmer amaranth control, with 84% control from metribuzin alone and 96% control from metribuzin + TCM at 67 g ha^{-1}. Likewise, the addition of *S*-metolachlor to TCM at 67 g ha^{-1} increased entireleaf morningglory control from 82% alone to 100% with TCM. This research shows that TCM alone provides excellent residual weed control of broadleaf signalgrass and entireleaf morningglory, with suppression of Palmer amaranth (48-69% control). The addition of TCM increases the spectrum of activity and length of residual control for many common residual herbicides.

IMPACT OF SUBLETHAL DICAMBA AND GLYPHOSATE ON THREE CHIPPING POTATO CULTIVARS. M. J. Brooke*; North Dakota State University, Fargo, ND (93)

ABSTRACT

The increase weedy species resistant to glyphosate has led to the development and release of dicamba resistant soybean varieties. However, with the increased utilization of dicamba, herbicide off-target injury has become a major issue for regional farmers. Investigating the impact of drift rates of these two ubiquitous agronomic herbicides, this research explores their effects on three irrigated chipping potato cultivars (Atlantic, Dakota Pearl, and Lamoka) as measured through visible injury, tuber quality reduction, and yield reduction. Herbicides were sprayed at the tuber initiation stage and consisted of dicamba at 99g ae ha^{-1}, glyphosate at 197g ae ha^{-1}, dicamba + glyphosate at 99g ae ha^{-1} + 197g ae ha^{-1}, and 20 g ae ha^{-1} + 40 g ae ha^{-1}, respectively, and an untreated control. Pooled across cultivars, at seven days after treatment (DAT), high dicamba + glyphosate caused the most damage, with 28% based on visible ratings. While low dicamba + glyphosate was not different from the untreated control. Furthermore, at 21 DAT, visible injury increased to 36% for the high dicamba + glyphosate treatment. The high combination of dicamba + glyphosate resulted in a 66% yield reduction compared to the untreated control, which averaged 910 cwt ha^{-1}. Tuber specific gravity was also lower for plants that had been sprayed with dicamba. Results from the two field trials suggest that not only can sublethal rates of dicamba + glyphosate greatly decrease potato yields, tuber specific gravity is also reduced influencing chipping quality.

GEOGRAPHICAL DISTRIBUTION OF CYHALOFOP-BUTYL AND PENOXSULAM RESISTANT ECHINOCHLOA SPECIES IN KOREA. D. KIM*[1], J. Kim[2], S. Lim[3]; [1]Seoul National University, Seoul, South Korea, [2]National Institute of Agricultural Sciences, Wanju, South Korea, [3]Universtiy of Illinois, Urbana-Champaign, IL (94)

ABSTRACT

Echinochloa species is one of the most problematic weeds in rice cultivation and the evolution of herbicide resistance in *Echinochloa* species has made this species even more problematic and difficult to manage. The present study was conducted to reveal the geographical distribution of penoxsulam and cyhalofop-butyl resistant barnyardgrass (*Echinochloa crus-galli* (L.) Beauv.) and late watergrass (*Echinochloa oryzicola* Vasing) in Korea. The level of herbicide resistance was higher in *E. oryzicocal* than in *E. crus-galli* for both herbicides. Geographical distribution analyses revealed that herbicide resistant *E. oryzicola* was relatively more evenly distributed than *E. crus-galli* in all four regions of Korea. Our results thus suggest that herbicide resistance is more evolved in *E. oryzicola* than in *E. crus-galli* and herbicide resistant *E. oryzicola* is distributed geographical more widely and evenly than *E. crus-galli* in paddy fields of Korea.

WEED MANAGEMENT IN SAFFRON. M. A. Haidar*; American University of Beirut, BEIRUT, Lebanon (95)

ABSTRACT

EVALUATION OF PYRACLONIL FOR ITS WEED CONTROL EFFICACY AND CROP SAFETY IN CALIFORNIA RICE. A. S. Godar*[1], K. Al-Khatib[1], J. Gutierrez[2]; [1]University of California, Davis, Davis, CA, [2]Nichino America, Inc., Fresno, CA (96)

ABSTRACT

IR-4 PROJECT: UPDATE AND NEW PROGRAMS TO ADDRESS SPECIALTY CROP GROWER NEEDS. D. Kunkel*[1], R. B. Batts[2], M. J. Braverman[3], J. Baron[4]; [1]Rutgers University, Princeton, NJ, [2]NCSU IR-4 Field Research Center, Fremont, NC, [3]Rutgers University, princeton, NJ, [4]IR-4 Project, Hillsborough, NJ (97)

ABSTRACT

IR-4 had a successful year in 2018 with nearly 1,000 new used posted from IR-4 research. Many of the new uses included herbicide label expansions, on products such as clethodim, clopyralid, fomesafen, flumioxazin, sulfentrazone and others. For 2019 herbicide residue and crop safety work, IR-4 is doing research on diquat and clopyralid on grape, flumioxazin on tropical fruit, glufosinate on several crops with directed treatments to row middles, quinclorac on orchard crops, triclopyr on sugarcane, trifloxysulfuron on strawberry, and others. In 2018, IR-4 initiated a new program to better service the needs of the IR-4 stakeholders, the Integrated Solutions (IS) Research Program. Integrated Solutions is a hybrid of the existing Food Use, Pest Problems Without Solutions (PPWS) research and elements of the traditional Biopesticide research program. Among the six IS priorities selected for 2019 investigations, control of parasitic weeds in California tomato production was selected as the only herbicide project. The IR-4 biopesticide program will also be looking at weed control in organic production across fruit, vegetable and hemp production. The program continues to develop and evolve to most efficiently provide pest control solutions to US growers.

CRANBERRY RESPONSE TO RATE AND APPLICATION TIMING WITH FLUMIOXAZIN AND SULFENTRAZONE. B. L. Carr[1], T. E. Besancon*[2]; [1]Rutgers University, Chatsworth, NJ, [2]Rutgers University, CHATSWORTH, NJ (98)

ABSTRACT

In 2017, New Jersey cranberry production estimated 29.6 million kg of cranberries at a farm value of $28 million (USDA 2017). New Jersey cranberry production is concentrated in the Pine Barrens coastal plain where sandy acidic soils are optimal for cranberry. Due to the specific edaphic conditions and perennial nature of cranberry production, weed control remains a major challenge. Therefore, through the IR-4 program, it is important to screen and evaluate herbicides already registered on other minor crops that can provide effective control of though-to-control weeds in cranberry production. Field studies were conducted in 2018 to test weed control efficacy and crop tolerance of two non-registered herbicides, sulfentrazone and flumioxazin. Trials were laid out in a 'DeMoranville' cranberry bog at the Rutgers P.E. Marucci Center in Chatsworth, NJ, as wells as in an 'Early Black' cranberry bed at Theodore H. Budd and Sons Farm in Southampton, NJ. Similar studies were also conducted in Wisconsin and Massachusetts. Treatments consisted of two different rates for each herbicide (flumioxazin at 143 and 286 g a.i. ha^{-1} and sulfentrazone at 280 and 420 g a.i. ha^{-1}) applied in spring when crop is still dormant at two different timings: early (bud swell cranberry stage) and late (cabbage head cranberry stages). A non-treated check (UNT) was included in each study. Necrosis of the terminal bud and cranberry stunting were rated 2, 4, and 8 weeks after treatment (WAT). Shoots were evaluated for primary and axillary shoot number, length, and number of fruits 8 WAT and at harvest. Yield was measured at harvest. Flumioxazin at 286 g a.i. ha^{-1} applied at the cabbage head stage caused the highest amount of terminal bud necrosis 2 and 4 WAT (60% and 14%, respectively). Flumioxazin at 143 a.i. ha^{-1} at bud swell and sulfentrazone at 280 g a.i. ha^{-1} at cabbage head stage caused less than 5% necrosis 2 WAT. By 4 WAT, necrosis symptoms virtually disappeared for sulfentrazone at 280 g a.i. ha^{-1} applied at bud swell. Flumioxazin at 286 g a.i. ha^{-1} applied at the stage resulted in the highest level of crop stunting 2 and 4 WAT (96 and 51%, respectively). Sulfentrazone at 280 g a.i. ha^{-1} applied at bud swell resulted in the lowest amount of stunting 2 and 4 WAT (41 and 8%, respectively). Overall, yield was extremely low for the DeMoranville cultivar, regardless of treatments. In the Early Black trial, sulfentrazone at 280 g a.i. ha^{-1} at bud swell did not significantly decrease fruit yield compared to UNT. Flumioxazin, regardless of application rate or timing, caused at least 90% yield reduction compared to UNT. Development of non-productive axillary shoots was multiplied by 3 in average with late application of sulfentrazone at 280 g a.i. ha^{-1} or flumioxazin, regardless of rate, for the DeMoranville cultivar.

USE OF DRONE IMAGING FOR ASSESSING WEED CONTROL AND DISEASE PRESSURE IN HIGHBUSH BLUEBERRY. M. G. Mars[1], D. C. Nuhn[1], B. L. Carr[2], T. E. Besancon*[3], P. V. Oudemans[3]; [1]Stockton University, CHATSWORTH, NJ, [2]Rutgers University, Chatsworth, NJ, [3]Rutgers University, CHATSWORTH, NJ (99)

ABSTRACT

New Jersey, the Garden State, is home to the largest diversity of specialty crops in the North East region. One in particular, the blueberry, is a major cash crop for which New Jersey ranks 5th in the United States. Understandably, weed detection and prevention remains crucial in order to prevent crop loss. In recent years, the technology behind unmanned aerial vehicles (UAVs) has jumped forward by leaps and bounds, allowing for cost-efficient, high-resolution, real-time spatial data collection and analysis. This study was conducted to evaluate the efficacy of drone imagery for weed detection and growth over time in highbush blueberry crops. The study focused on two rows of cultivar Duke blueberries. A study including various preemergence (PRE) herbicide treatments and a weedy check was set up in these two rows and plots were monitored throughout the growing season. The efficiency of small unmanned aerial vehicle (sUAS) detection was compared throughout the growing season with other detection methods, namely, the Canopeo application (http://www.canopeoapp.com/) and manual weed density counts. Two sensors were utilized for sUAS data collection: a broad band RGB (Red Green Blue) sensor and a narrow band multispectral (Blue, Green, Red, Red-Edge, and Near Infrared) sensor. The sensors (especially the multispectral one), though very useful for image capture and general field analysis, are limited by their resolutions. One issue that cropped up was being unable to differentiate between weeds and the edges of the bushes, as they had very similar reflectance values. The results showed high correlation levels between the Canopeo data and the RGB-based Green Leaf Index (GLI) data ($R^2 = 0.82$), and high correlation levels between the GLI data and the multispectral NDVI (Normative Difference Vegetative Index) data ($R^2 = 0.96$). The results also saw poor correlation levels between sUAS-gathered GLI data and weed density data (R^2=0.59), and between Canopeo data and weed density data (R^2=0.53). It is clear from both the RGB and multispectral imagery that the different herbicide PRE treatments expressed various degrees of weed control success, ranging from less than 20% control 35 weeks after treatment (WAT) with dichlobenil to 100% control 18 WAP with a combination of diuron, mesotrione, and oryzalin. However, additional studies are warranted to determine if some of the treatments tested may have negative effects on crop development, given the predominantly sandy texture of New Jersey soils. Future research will also be directed toward the use of machine learning for improving disease and weed tracking through the use of drone imagery.

HERBICIDE EVALUATIONS FOR ONTARIO GROWN QUINOA. R. E. Nurse*[1], M. Cowbrough[2]; [1]Agriculture and Agri-Food Canada, Harrow, ON, [2]Ontario Ministry of Agriculture, Food and Rural Affairs, Guelph, ON (100)

ABSTRACT

Quinoa (*Chenopodium quinoa*), a potential new specialty crop for some Canadian growing regions, currently has no registered herbicides available to manage competitive weeds. Growers will require herbicide registrations that provide selective control of common lambsquarters (*Chenopodium album*) while having low phytotoxicity on quinoa. The first of two studies was conducted at Guelph and Harrow, ON in 2015 and 2016. This study evaluated the phytotoxic effects of eight herbicides at proposed 1x and 2x overlap doses for each herbicide. Of the eight herbicides evaluated only two of the herbicides (s-metolachlor and pendimethalin) were within a margin of crop safety that was considered acceptable. To better test how application timing affected crop safety a second trial was established at Harrow, ON in 2017 and 2018. S-metolachlor and pendimethalin were applied at 4 different timings: pre-emergence, cotyledon, 2 to 4 leaf, and 6 to 8 leaf stages of the crop. Results demonstrated that s-metolachlor had a good margin of crop safety at all application timings, while pendimethalin was only acceptable when applied at the 6 to 8 leaf stage.

RESPONSE OF SWEETPOTATO TO FLURIDONE PREPLANT FOLLOWED BY IRRIGATION. S. Chaudhari*, K. M. Jennings, D. Monks, S. C. Smith, L. D. Moore; North Carolina State University, Raleigh, NC (101)

ABSTRACT

Field studies were conducted in 2017 and 2018 at the Horticultural Crops Research Station near Clinton, NC to determine sweetpotato response to fluridone PREPLANT. In 2017, herbicide treatments included fluridone at 112, 224, 336, 448, and 560 g ai ha^{-1} and flumioxazin at 108 g ai ha^{-1} PREPLANT [7 d before sweetpotato transplanting (DBP)]. In 2018, herbicide treatments were arranged in a 6 by 2 factorial design consisting of six fluridone rates (0, 112, 224, 336, 448, and 560 g ha^{-1}) PREPLANT (2 DBP) and two irrigation treatments [single irrigation event 0 d after transplanting (DAP) or sequential irrigation events 0 DAP followed by 4 DAP]. At each irrigation event, 1.9 cm of water was applied using a rainfall simulator to move the herbicide into the area where sweetpotato storage roots develop. In 2017, the

maximum visible sweetpotato injury at 28 DAP was 12% bleaching and 12% stunting from 560 g ha^{-1} fluridone. However, visible sweetpotato injury at 28 DAP from all other fluridone rates was < 5% bleaching and 3% stunting. In 2018, number of irrigation events did not influence visible sweetpotato vine injury, stand count, and yield of any sweetpotato grades. At 28 DAP, ≤ 5% plant stunting was present regardless of fluridone rate. In both studies, fluridone rate did not affect stand count and yield of no.1, jumbo, or marketable sweetpotato storage roots. Based on these results, fluridone herbicide has potential for registration in sweetpotato.

MUSCADINE GRAPE (*VITIS ROTUNDIFOLIA*) TOLERANCE TO 2,4-D CHOLINE APPLIED AS A DIRECTED SPRAY. C. D. Holmberg*[1], K. M. Jennings[2]; [1]North Carolina State University, Mills River, NC, [2]North Carolina State University, Raleigh, NC (102)

ABSTRACT

Muscadine Grape (*Vitis rotundifolia*) Tolerance to 2, 4-D Choline Applied as a Directed Spray.

C. D. Holmberg, W. E. Mitchem, K. C. Sims and K. M. Jennings; N. C. State University, Mills River, NC, and N. C. State University, Raleigh, NC.

Viticulturalists have long feared the potential for grape vine injury resulting from the off target movement of 2, 4-D ester or amine into vineyards. It is well documented that grape is very sensitive to direct foliage contact from 2, 4-D.

With the development of 2, 4-D choline for use in 2, 4-D tolerant crops, there is an interest in the potential for 2, 4-D choline use in small fruit crops. The likelihood of physical drift from 2, 4-D choline is 90 % less likely than from traditional 2, 4-D formulations. 2, 4-D choline volatility is 87.5% and 96% less than the amine and ester formulations, respectively. The Embed ™ formulation of 2, 4-D choline is currently registered for use in pome and stone fruit as well as pistachio orchards and has offered stone fruit growers more flexibility in application times for these crops.

Muscadine is a native grape species in the Southeastern United States grown commercially for fresh market consumption and wine production. Commercial muscadine production in NC is located across the coastal plain and piedmont region, in areas where glyphosate resistant weeds occur in significant populations. Muscadine is a very hardy, vigorous plant making it ideal to do initial evaluations for *Vitis* species sensitivity to 2, 4-D choline

In 2018, trials were conducted to evaluate muscadine tolerance to 2, 4-D choline in a vineyard located in Lincoln County, NC, which consisted of 9 year old "Nesbitt" muscadine vineyard. The herbicide was applied using a CO_2 pressurized backpack sprayer fitted with 11002 TeeJet flat fan nozzles calibrated to deliver 187 L ha^{-1} at 276 kPa. Treatments consisted of 2, 4-D choline applied either once or twice at 0.53, 1.06, 1.6, and 2.13 kg ha^{-1}. The single application, as well as the first of the sequential applications were applied May 31, 2018 during muscadine bloom. The treatments requiring a second application were sprayed July 27, 2018. No spray additives or surfactants were included. 2, 4-D choline was applied as a directed spray at the base of the vines.

Visual observations assessing crop injury were collected periodically throughout the summer until harvest. In order to quantify any impact on growth the increase in trunk cross-sectional area data was collected as well as yield data.

Injury symptoms were observed but were very minimal and did not differ between applications rates or number of applications. Ratings for crop injury ranged from 0 to 11% during the course of the summer through harvest. Applications of 2, 4-D choline did not reduce trunk cross-sectional area increases relative to the non-treated check nor was yield affected.

INTERSEEDED COVER CROP TOLERANCE TO HERBICIDES IN NON-TRANSGENIC SWEET CORN. E. Peachey, A. Donaldson*; Oregon State University, Corvallis, OR (103)

ABSTRACT

DEEP LEARNING FOR IMAGE-BASED WEED DETECTION. J. Yu*[1], S. M. Shaun[2], A. W. Schumann[2], N. Boyd[1]; [1]University of Florida, Balm, FL, [2]University of Florida, Wimauma, FL (104)

ABSTRACT

Weeds generally occur in non-uniform distribution in turfgrass. Precision herbicide application can significantly reduce herbicide input. The detection system is the critical component within smart herbicide applicators that is used to recognize target weeds. This research revealed several deep convolutional neural network (DLCNN) architectures that are remarkably accurate at detecting various broadleaf and grassy weeds in bermudagrass [*Cynodon dactylon* (L.) Pers.]. VGGNet achieved high F_1 score values (>0.95) and out-performed GoogLeNet for detection of dollar weed (*Hydrocotyle spp.*), old world diamond-flower (*Hedyotis cormybosa* L. Lam.), and Florida pusley (*Richardia scabra L.*) in actively growing bermudagrass. VGGNet generally out-performed AlexNet and GoogLeNet at detecting crabgrass species (*Digitaria* spp.), doveweed [*Murdannia nudiflora* (L.) Brenan], dallisgrass (*Paspalum dilatatum* Poir.), and tropical signalgrass [*Urochloa subquadripara* (Trin.) R.D. Webster.] in actively growing bermudagrass. VGGNet exhibited excellent performance (overall accuracy = 1.00) at detecting all grassy weed species in both low and high weed density conditions. DetectNet was the most effective DCNN architecture at detecting annual bluegrass (*Poa annua* L.) or *Poa annua* growing with various broadleaf weeds in dormant bermudagrass, with F1 scores >0.99. Because of the high level of performances, we conclude that DLCNN-based weed detection can be an effective decision system in smart herbicide sprayers.

ROLE OF HERBICIDE MOVEMENT THROUGH ORGANIC MULCH ON WEED CONTROL EFFICACY IN NURSERY CONTAINER PRODUCTION. D. Saha*[1], C. Marble[2], B. Pearson[1], H. Perez[3], G. MacDonald[3], D. Odero[4]; [1]Mid-Florida Research and Education Center, University of Florida, Apopka, FL, [2]University of Florida, Apopka, FL, [3]University of Florida, Gainesville, FL, [4]University of Florida, Belle Glade, FL (105)

ABSTRACT

Experiments were conducted at Mid-Florida Research and Education center, Apopka, FL in 2018 to assess herbicide movement through organic mulch materials including pinebark, pinestraw, and hardwood. Weed species evaluated were large crabgrass [*Digitaria sanguinalis* (L.) Scop.], garden spurge (*Euphorbia hirta* L.), and eclipta [*Eclipta prostrata* (L.) L.]. Liquid formulations of prodiamine, dimethenamid-P + pendimethalin, and indaziflam were applied to nursery containers filled with standard potting soil and were either mulched with the above listed materials at a depth of 5.1 cm or left non-mulched. After herbicide treatments were applied, 3.8 cm of irrigation was applied over 3 days and then all mulch was removed to determine how much herbicide reached the soil surface following application. Data collection for bioassay studies included weed counts at 2 and 4 weeks after treatment (WAT) and weed fresh weights at 4 WAT. Control of each weed species in pots that were originally mulched was then compared to control of each weed species that contained no mulch at the time of application using the Proc GLM procedure in ANOVA. Quantification of these herbicides was also performed using chemical assays from the soil samples collected from below the mulch layers. Results from bioassay showed that only 67% eclipta control was observed in pots originally mulched with hardwood, which indicates that indaziflam was more tightly bound to this mulch compared with pinebark or pinestraw. Large crabgrass data showed that pinebark (65% control) was the only mulch type that caused a significant reduction in prodiamine efficacy. Dimethenamid-P + pendimethalin efficacy on garden spurge was reduced in pots originally mulched with hardwood or pinebark, but all treatments provided ≥94% control. Chemical assays showed that approximately 20% of pendimethalin, prodiamine, and indaziflam that was applied reached the soil surface when mulch was present during the application. More dimethenamid-P reached the soil surface than any other herbicide, with 67% being retained by the pinebark mulch.

CONTROL STRATEGIES FOR NOSTOC: A HEALTH AND SAFETY CONCERN IN CONTAINER NURSERIES. J. Neal*, C. D. Harlow, H. Lin; North Carolina State University, Raleigh, NC (106)

ABSTRACT

Nostoc is a cyanobacterium that produces thick, gelatinous masses on gravel roadways and production surfaces in container nurseries, where it creates a slipping hazard to nursery workers. On-farm experiments were established in 2017 and 2018 at a wholesale container nursery with a history of thick *Nostoc* infestations to evaluate physical disturbance with a tractor box blade, diruon and simazine efficacy +/- physical disturbance, and curative applications of other biocides for *Nostoc* suppression. Nostoc recovered rapidly from disturbance in early summer but was slow to recover from disturbance in early autumn. Diuron suppressed *Nostoc* when applied at 0.5 to 1 lb ai/A. Applied at 0.25 lb ai//a,, diuron was more effective when applied following gravel disturbance. Simazine suppressed nostoc in one run of the experiment but was ineffective in a second run. Curative applications of pelargonic acid, a peroxide sanitizing agent, or diquat were ineffective. Two applications of mancozeb suppressed *Nostoc* cover by about 50%. Captain XTR (copper diethanolamine) provided 71 to 86% reduction in *Nostoc* ground cover. The most consistently effective treatments in this study were gravel disturbance followed by diuron application or Captain XTR applied twice at 14 day interval.

ON FARM EVALUATION OF MULTIPLE MULCH MATERIALS FOR LONG-TERM WEED CONTROL IN CONTAINER NURSERIES. C. Marble*[1], S. T. Steed[2]; [1]University of Florida, Apopka, FL, [2]University of Florida/IFAS Extension, Seffner, FL (107)

ABSTRACT

Weed management in container-grown ornamentals is becoming increasingly expensive as growers must rely solely on handweeding and preemergence herbicides. Use of loose-fill organic mulch materials has been heavily researched as an alternative to traditional weed management techniques and has been shown to be highly effective. However, depending on the nursery location and availability, mulch may be cost prohibitive or difficult to apply. Another disadvantage is that in order for mulch to be used, containers usually need to be filled no more than 2.5 cm from the top rim of the container to allow for a lip to hold the mulch, which reduces space for root growth. These disadvantages could be potentially avoided by using mulch in larger container-grown crops which are 1) in production for a longer period of time, allowing growers more time to recoup the initial cost of mulch application and 2) any negative effects from reduced space for available roots would be minimized in larger containers. Experiments were conducted from 2017 to 2018 at three different nursery sites and at University of Florida Research and Education Centers in Apopka and Balm, FL to evaluate the use of mulch as a weed management tool in large container-grown ornamentals. Treatments included pinebark nuggets, hardwood mulch, and sawdust, both alone and in combination with a tackifier, a paper waste slurry, the paper waste slurry + pinebark, a plastic mulch that was wrapped around containers, a granular herbicide control (oxyfluorfen + pendimethalin) at standard label rates, and a nontreated, non-mulched control that was used for comparison. Each site was visited monthly and all pots were weeded, recording both the time to weed each pot and weed fresh weight. Weed control data were converted to percent reductions of either weeding time or weed weight based on the nontreated control. Growth of *Ligustrum japonicum* was monitored at the Research Centers in Apopka and Balm. Each study was conducted at the various locations for approximately 6 months. Overall, the plastic mulch provided the greatest reduction in weeding time (92%) along with the pinebark mulch treatments, which were similar. While sawdust provided acceptable (>80%) control at early evaluation dates, the highest weeding times and weed weights were recorded in these treatments overall. The newspaper slurry was effective at early evaluation dates but the material receded from the edges of the container after approximately 3 months, allowing weed growth. Growth data showed that there was no difference in ligustrum growth with any mulch treatment. This research demonstrates that similar to previous findings, mulch can be used as a long-term management tool in container nurseries. Large particled materials, such as pine bark, that have low water holding capacity, drain quickly, and degrade slowly will likely be suitable materials in nursery environments. Use of plastic mulch was also highly effective but may not be suitable for all production situations.

COMBINATION TREATMENTS OF SIMAZINE AND TRIFLOXYSULFURON FOR *POA ANNUA*. E. B. De Castro*[1], M. P. Richard[2], J. D. McCurdy[3]; [1]Mississippi State University, STARKVILLE, MS, [2]Mississippi State University, Starkville, MS, [3]Mississippi State University, Mississippi State University, MS (108)

ABSTRACT

Herbicide resistant annual bluegrass (*Poa annua*) is often difficult to control with a single herbicide mode of action. An alternative to overcome this problem is the combination of different herbicide modes of action. Field research was conducted to evaluate simazine and trifloxysulfuron tank-mixtures for control of two known photosystem II inhibiting herbicide resistant annual bluegrass populations. Research was conducted at Mississippi State University in 2017 and 2018 to evaluate the effects of treatments on control of annual bluegrass. Research was conducted as a randomized complete block design, with 4 replications. Plot size was 2 by 3 m. Treatments included: simazine (1120 g a.i. ha^{-1}), trifloxysulfuron (18.4 g ha^{-1}), simazine (560 g ha^{-1}) + trifloxysulfuron (18.4 g ha^{-1}), simazine (1120 g ha^{-1}) + trifloxysulfuron (18.4 g ha^{-1}), simazine (2240 g ha^{-1}) + trifloxysulfuron (18.4 g ha^{-1}), and pronamide (1620 g ha^{-1}). With the exception of the pronamide treatment, a nonionic surfctant was included (0.25 %v v^{-1}). Treatments were applied in a water carrier volume of 374 L ha^{-1} using a CO_2 pressurized backpack sprayer. Control of annual bluegrass was visually evaluated 2, 4, 6 and 8 weeks after application (WAA). Data were subject to analysis of variance, and means were compared by least significant differences (LSD) ($\alpha = 0.05$) using Student-Newman-Keuls test within SAS procedure GLIMMIX (version 9.4).

In 2017, when assessed 2 WAA, no treatment controlled annual bluegrass greater than 57%; however, pronamide presented the lowest level of control (23%). Evaluated 4 and 6 WAA, all treatments increased in control except pronamide (20%) and simazine alone (30%). When assessed 8 WAA, treatments with trifloxysulfuron alone and in combination with simazine presented the highest control >73%.

In 2018, when assessed 2 WAA, no treatment controlled annual bluegrass greater than 35%; however, treatments of simazine alone and in combination with trifloxysulfuron controlled annual bluegrass greater than pronamide (11%) or trifloxysulfuron alone (10%). Evaluated 4 WAA, treatments containing trifloxysulfuron alone and in combination with simazine completely controlled annual bluegrass (100%). By 8 WAA, trifloxysulfuron with simazine (1120 and 2240 g ha^{-1}) maintained 100% control. At 8 WAA, pronamide only controlled annual bluegrass 66%.

Trifloxysulfuron alone or in combination with simazine controlled annual bluegrass greater than pronamide in both years; however, the addition of simazine does appear to enhance trifloxysulfuron control relative to that of trifloxysulfuron alone. These results challenge the recommendation of combining two modes of action for the control of herbicide resistant annual bluegrass. Future research could investigate the antagonistic nature of these two active ingredients, as well as other advantages or disadvantages to the mixture (ex. turf phytotoxicity and enhanced broadleaf weed control).

RATE RESPONSE OF SELECT GRASS WEEDS TO PINOXADEN. J. M. Peppers*; Auburn University, Auburn, AL (109)

ABSTRACT

Pinoxaden is an acetyl-CoA carboxylase (ACCase) inhibiting herbicide that is a member of the phenylpyrazolin chemical family. Pinoxaden was released for use in turfgrass under the trade name Manuscript (Syngenta, Basal, Switzerland) in 2018. Manuscript is applied post-emergence at labelled rates of 35.5-71 g ai ha^{-1}. A greenhouse evaluation was conducted from 2018-2019 at the Auburn University Weed Science Greenhouse located in Auburn, Alabama. To evaluate select turfgrass weed's response to pinoxaden, eight different species of grassy weeds were evaluated: yellow foxtail (*Setaria glaucus*), annual bluegrass (*Poa annua*), rough-stalk bluegrass (*Poa trivialis*), large crabgrass (*Digitaria sanguinalis*), dallisgrass (*Paspalum dilatatum*), goosegrass (*Eleusine indica*), broadleaf signalgrass (*Brachiaria platyphylla*) and perennial ryegrass (*Lolium perenne*). Applications were made six weeks after germination for all species evaluated. The applied treatments were ten different rates of pinoxaden at 4, 10, 19, 39, 77, 156, 310, 621, 1240, and 2490 g ai ha^{-1} with Adigor surfactant (methyl ester of fatty acids, alcohol ethoxylate, and petroleum distillates) at 0.5% v/v included in all treatments. These treatments were compared to a non-treated control. At the conclusion of the trial, 35 DAT, all rates of pinoxaden injured perennial ryegrass 100%. Pinoxaden at 10 g ha^{-1} and above injured crabgrass and broadleaf signalgrass 100%. Pinoxaden at 19 g ha^{-1} and above injured dallisgrass and yellow foxtail >95%. Pinoxaden at 77 g ha^{-1} and above injured rough-stalk bluegrass >85%. Pinoxaden at 156 g ha^{-1} and below injured goosegrass <16.5%. Pinoxaden at 1240 and 2490 g ha^{-1} injured goosegrass >95%. Pinoxaden at 310 g ha^{-1} and below injured annual bluegrass <5% while pinoxaden at 2490 g ha^{-1} injured annual bluegrass 65%. Based on these results, the tested weeds can be ranked from most to least pinoxaden susceptibility as such: perennial ryegrass > large crabgrass = broadleaf signalgrass > dallisgrass = yellow foxtail> rough-stalk bluegrass > goosegrass > annual bluegrass.

SEASONAL GOOSEGRASS (*ELEUSINE INDICA*) EMERGENCE IN TURFGRASS. M. T. Elmore*[1], D. P. Tuck[2], K. Diehl[1]; [1]Rutgers University, New Brunswick, NJ, [2]Rutgers University, North Wales, PA (110)

ABSTRACT

The objective of this research was to determine goosegrass seedling emergence patterns in New Jersey turfgrass and develop a temperature-based model to predict seasonal emergence. A total of five experiments were established at three sites. Experiments were conducted at two different sites within the same fairway on a golf course in East Brunswick, NJ in 2017 and a golf course fairway in Manalapan NJ in 2018. Two other experiments evaluated emergence at different mowing heights at the Rutgers Hort. Farm No. 2 in North Brunswick, New Jersey in 2017 and 2018. Goosegrass seedlings were counted and removed on a weekly basis from April through October within fixed circles, replicated four times for each treatment and location. Plots at the Rutgers site were subjected to three different ground cover treatments; bare ground, perennial ryegrass (PRG; *Lolium perenne*) mowed at 1.3 cm (fairway), and PRG mowed at 6.4 cm (rough). Fixed circles were sized 1000 cm^2 within each 1.0 by 1.0 m plot. At the golf course locations, plots were maintained as a golf course fairway at a 1.25 cm mowing height and fixed circles were sized 500 cm^2 within each 1.0 by 1.0 m plot. Soil temperature was monitored at a 5.0 cm depth at all locations. Soil volumetric water content was measured at the Rutgers site.

The sum of goosegrass plants that emerged in each plot throughout the season was calculated. Emergence duration was also determined as the number of days between observation of first goosegrass seedling emergence in the spring and the last seedling emerged at the end of the season. The cumulative percent of total yearly emergence was also determined on each evaluation date. Data from all sites were combined and subject to non-linear regression in Prism using a Weibull function with cumulative emergence as the dependent variable and day of year or growing thermal time as the independent variable and used to calculate 50 and 90 percent emergence thresholds.

Goosegrass emergence was first observed on 26 and 10 May 2017 at the Rutgers site and East Brunswick sites, respectively. In 2018, emergence was noted in bare soil plots on 8 May and in fairway and rough height plots on 14 May in East Brunswick and 8 May in Manalapan. Emergence totals but not emergence duration were combined across years. A mean of 1052 plants 1000 cm^{-2} emerged annually in bare soil plots, which was more than the 401 and 255 plants 1000 cm^{-2} that emerged in fairway and rough height plots, respectively. Bare soil treatment increased the number of days of emergence in both 2017 and 2018 (142 and 104 days, respectively) compared to fairway (78 and 106 days, respectively) and rough (85 and 120 days, respectively) height treatments. When cumulative emergence data were combined across locations, thermal time-based models did not predict goosegrass emergence better than day-of-year. The day-of-year and thermal time values required to achieve 50 and 90 percent cumulative emergence were highly variable across sites and years. Goosegrass biotype differences may be responsible for variable emergence across sites.

HERBICIDE APPLICATION TIMING TO CONTROL BULBOUS BUTTERCUP (*RANUNCULUS BULBOSUS*) IN A PASTURE. R. S. Chandran*; West Virginia University, Morgantown, WV (111)

ABSTRACT

Bulbous buttercup (*Ranunculus bulbosus*) is a perennial weed considered to be toxic to animals, especially horses, by virtue of the glycoside ranunculin. It is prevalent in Appalachian pastures and hayfields, and can displace desirable forages if left uncontrolled. Seeds germinate during fall months forming rosettes that can remain dormant during winter months. The weed becomes noticeable upon bloom time in early spring (mid-April to May). A field experiment was conducted at Jane Lew, West Virginia, (39°05'28.3"N; 80°24'45.6"W) to compare fall (September 28, 2017) and spring (April 30, 2018) application timing of 2,4-D + dicamba (1.61+ 0.56 kg a.i. ha^{-1}) or diflufenzopyr + dicamba (0.112 + 0.28 kg a.i. ha^{-1}) to control bulbous buttercup during the growing season. Methylated seed oil (MSO) was added to the herbicide treatments (1% vol/vol) as an adjuvant. Weed control ratings recorded during the growing season (May 17, 2018) indicated that spring application of the herbicides provided acceptable levels (89 to 94%) of weed control, whereas, fall applications failed to do so (30 to 45%). Treatments containing 2,4-D + dicamba or diflufenzopyr + dicamba were equally effective to control the weed. Based on a GDD Model available through Climate Smart Farming at Cornell University (http://climatesmartfarming.org/), spring application was carried out when GDD_{10C} recorded 129 at this location. Bulbous buttercup plants were mostly in the vegetative stage at this time with some plants in the early bloom stage. Soil moisture levels preceding and following treatments were adequate.

HAYFIELD SWARD RESPONSE TO HERBICIDE-IMPREGNATED DRY FERTILIZER. W. C. Greene[1], M. L. Flessner[2], K. W. Bamber*[2], P. L. Burch[3], S. Flynn[4]; [1]Virginia Tech, Virginia Tech, VA, [2]Virginia Tech, Blacksburg, VA, [3]Corteva Agriscience, Christiansburg, VA, [4]Corteva Agriscience, Lees Summit, MO (112)

ABSTRACT

Effective weed control in hayfields and pastures is essential in maximizing desirable forage production. Applying herbicides impregnated on fertilizer reduces application cost and allows greater flexibility in weather conditions at application. However, little information is available regarding weed control efficacy and sward response to herbicides on fertilizer. A study was conducted in 2018 in Blacksburg, Virginia in order to evaluate the effect of herbicide-impregnated fertilizer applications on weed control and forage production. Aminopyralid plus 2,4-D, and aminopyralid plus metsulfuron-methyl was impregnated onto dry fertilizer and applied to a hayfield. Fertilizer without herbicide was applied as a nontreated control. Biomass production and transect data were taken every 30 days after application for forage, legume, weedy grasses, and broadleaf weed species up to 150 days. Cumulative forage biomass was highest with aminopyralid plus 2,4-D (4873 kg ha^{-1}) compared to aminopyralid plus metsulfuron-methyl (2845 kg ha^{-1}) and the nontreated control (2852 kg ha^{-1}). Cumulative legume biomass and cumulative broadleaf weed biomass were greatest in the nontreated control compared to both herbicide treatments. Cumulative weedy grass biomass was highest with aminopyralid plus metsulfuron-methyl compared to the nontreated control. There was no difference between treatments for cumulative forage transect data and cumulative weedy grass transect data. The nontreated control resulted in greater coverage of legume species and broadleaf weed species compared to both herbicide treatments. This study indicates that herbicides on fertilizer are a viable option for weed control and improve hayfield productivity. Future research is needed to corroborate these findings and evaluate efficacy on other weeds, particularly difficult-to-control perennial weeds.

STRATEGIES FOR CONTROLLING WILD POINSETTIA IN ALABAMA ROADSIDES. A. P. Boyd*[1], E. Guertal[1], D. Han[1], H. Peavey[2]; [1]Auburn University, Auburn, AL, [2]Alabama Department of Transportation, Montgomery, AL (113)

ABSTRACT

Strategies for Controlling Wild Poinsettia in Alabama Roadsides. A.P. Boyd[1], D.Y. Han[1], E.A. Guertal[1], J.M. Hodnett[2], H. Peavey[2]; [1]Auburn University, Auburn, AL; [2]Alabama Department of Transportation, Montgomery, AL.

Abstract

The prevalence of wild poinsettia (*Euphorbia heterophylla)*in roadsides is becoming a major problem for rights of way management. The vertical growth habit of wild poinsettia is a major concern for motorists, because of reduced visibility and other safety issues. Data regarding the control of wild poinsettia in rights of way is scarce. Two field trials were conducted in 2018 to evaluate different chemicals and rates for pre-emergent (PRE) and post-emergent (POST) control of wild poinsettia on a roadside east of Selma, AL. The pre-emergent trial was initially applied on March 15, 2018. Pre-emergent treatments were indaziflam (0.25, 0.35 L ha^{-1}), metribuzin (0.74 kg ha^{-1}), sulfentrazone (0.84L ha^{-1}), flumioxazin (0.84 kg ha^{-1}), and a non-treated control. All treatments included a drift retardant at a rate of 88.7 mL/378.5L of water.The post-emergent trial was initially applied on May 14, 2018. Post-emergent treatments included aminocyclopyrachlor (0.29, 0.58, 0.88 L ha^{-1}), imazapic (0.15 L ha^{-1}), indaziflam (0.25 L ha^{-1}) + aminocyclopyrachlor (0.29 L ha^{-1}), indaziflam (0.35 L ha^{-1}) + aminocyclopyrachlor (0.29 L ha^{-1}), , metribuzin (0.74 kg ha^{-1}) + aminocyclopyrachlor (0.29 L ha^{-1}), sulfentrazone (0.84 L ha^{-1}) + aminocyclopyrachlor (0.29 L ha^{-1}), , imazapic (0.15 L ha^{-1}) + indaziflam (0.25 L ha^{-1}), imazapic (0.15 L ha^{-1}) + indaziflam (0.35 L ha^{-1}), imazapic (0.15 L ha^{-1}) + metribuzin (0.74 kg ha^{-1}), imazapic (0.15 L ha^{-1}) + sulfentrazone (0.84 L ha^{-1}), and a non-treated control. All treatments were mixed with a surfactant at 2.3 L ha^{-1}and a drift retardant at a rate of 88.7mL/378.5L of water.Both trials were rated for weed cover, weed control, and turfgrass density percentages on a monthly basis. The pre-emergent trial showed that at 124 days after treatment (DAT), indaziflam (0.25, 0.35 L ha^{-1}), sulfentrazone, and flumioxazin yielded the highest level of wild poinsettia control with ranges of 89-97.5%, respectively. Plots receiving metribuzin were not significantly different than the control plots. However, control of wild poinsettia created an opportunity for the germination and growth of other weed species. The plots receiving flumioxazin maintained the highest level of control over a wider spectrum of weeds when compared to the other treatments. The post-emergent trial was concluded 64 DAT. The highest level of control was observed in the treatments of aminocyclopyrachlor (0.29, 0.58, 0.88 L ha^{-1}), sulfentrazone + aminocyclopyrachlor (0.29 L ha^{-1}), metribuzin (0.74 kg ha^{-1}) + aminocyclopyrachlor (0.29 L ha^{-1}), indaziflam (0.25 L ha^{-1}) + aminocyclopyrachlor (0.29 L ha^{-1}), and indaziflam (0.35 L ha^{-1}) + aminocyclopyrachlor (0.29 L ha^{-1}). Overall control ranged from 73.3-93.3% with sulfentrazone + aminocyclopyrachlor (0.29 L ha^{-1}) yielding the highest control at 93.3%. All treatments that included imazapic resulted in high levels of injury and should be avoided.

WSSA HOSTS US EPA SUMMER TOUR THROUGH NEBRASKA AND IOWA. G. Kruger*[1], J. Gizotti de Moraes[1], B. Canella Vieira[1], J. Schroeder[2], L. Van Wychen[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]USDA Office of Pest Management Policy, Arlington, VA, [3]WSSA, Alexandria, VA (114)

ABSTRACT

While making registration decision on pesticides, US EPA has to evaluate both the benefits and risks of these products before they are registered or reregistered for use. No tasks have been bigger and more controversial in the herbicide market than dicamba and atrazine. With a reregistration decision on dicamba impending, the week of July 30th, 2018, a dozen EPA employees from the national office in Washington DC and from the Region 7 office in Kansas City hit the road to tour Nebraska and western Iowa as an event sponsored by both WSSA and the Iowa Farm Bureau in order to better understand how the two herbicides are being used, where they are being used and what unintended consequences have resulted from the use of the products. During the tour, the group had the opportunity to meet with some of the agronomists, retail managers, growers and other key stakeholders as well as with representatives from both the Nebraska and Iowa Departments of Agriculture. Moreover, the group had the opportunity to hear from numerous different individuals in both support of and concern of the use of dicamba during an open stakeholder meeting hosted by the University of Nebraska-Lincoln. The group also had the opportunity to look at some of the research related to drift and off-target movement at the West Central Research and Extension Center's Pesticide Application Technology Laboratory near North Platte and to visit couple of farms in western Iowa where the group was able to see the use and impact that atrazine has had on corn production and its benefit of reducing soil erosion as well as to see drones in use, and operate farm equipment including a 120'

boom sprayer. Individuals that made the trip were able to incorporate the diverse interests in agriculture that represent Nebraska and Iowa. An exceptional opportunity that helped in the information-gathering evaluation process trying to figure out the best path forward.

PARTNERING WITH INDUSTRY TO DELIVER WEED SCIENCE CONTINUING EDUCATION TO FLORIDA&RSQUO;S TURFGRASS PROFESSIONALS. F. Fishel*[1], H. Russo[2]; [1]University of Florida, Gainesville, FL, [2]Florida Turfgrass Association, Lakeland, FL (115)

ABSTRACT

PARTERNING WITH PRIVATE INDUSTRY TO DELIVER WEED SCIENCE CONTINUING EDUCATION TO FLORIDA'S TURFGRASS PROFESSIONALS. F.M. Fishel*[1], H. Russo[2]; [1]University of Florida, Gainesville, FL, [2]Florida Turfgrass Association, Lakeland, FL

ABSTRACT

Turfgrass management professionals in Florida are required to earn approved continuing education units (CEUs) to keep licenses and certifications current, such as state pesticide licenses, Certified Crop Advisor, and Florida Nursery Growers and Landscape Association. This audience has traditionally attended live face-to-face programs offered by the University of Florida (UF) and commodity and trade associations. Resource challenges have increased the need for more efficient means of educational program delivery to these audiences. Faced with these challenges, extension educators have become more creative for efficient information delivery mechanisms to save miles traveled, time, and costs. Forming partnerships with private industry can empower extension professionals to differently strategize methods of program delivery and effectively and efficiently reach broader audiences. Since 1953, the Florida Turfgrass Association (FTGA) has been an advocate for promoting the turfgrass industry with support for extensive research, continuing education, and opportunities for turfgrass professionals to network with their colleagues. The major objective of our work was to provide an educational opportunity by offering CEUs to those who work primarily in the turfgrass industry, but also those employed by other agricultural sectors, including vegetation management. UF plans the agenda, solicits the host sites, and invites the speakers. FTGA's role is marketing the program to their membership and other relevant professional associations, managing attendee registrations, and collecting program fees. Our 2018 single-day distance educational event focused on weed management and reached more than 300 professionals at 20 sites using Mediasite® technology delivery.

THE UNIVERSITY OF TENNESSEE'S COMPREHENSIVE HERBICIDE STEWARDSHIP PROGRAM. N. Rhodes*[1], L. E. Steckel[2], T. Mueller[1], D. McIntosh[1]; [1]University of Tennessee, Knoxville, TN, [2]University of Tennessee, Jackson, TN (116)

ABSTRACT

Due to numerous cases of off-target movement of auxinic herbicides to tobacco and other sensitive high value crops, we began a comprehensive educational program in 2011 stressing the importance of proper stewardship with the use of pasture herbicides. Our goals were to reduce the occurrence and impact of off-target damage to tobacco and other sensitive, high value crops; and to create educational materials and other tools to help with the diagnosis of suspected cases of off-target damage. The initial funding was obtained via a grant and continued funding from Philip Morris International. Later, additional funding was obtained from Altria Client Services, Dow AgroSciences, DuPont Crop Protection, and Monsanto. We focused on four crops (tobacco, cotton, tomato and grape) and five herbicides (2,4-D, dicamba, aminopyralid, aminocyclopyrachlor and picloram) for the creation of educational materials and diagnostic tools. These include still images, time lapse videos and fact sheets; and we made them available through our initial website, herbicidestewardship.utk.edu; it became accessible in 2014. Later it was simplified to herbicidestewardship.com. In 2016, 2017, and again in 2018, widespread problems with dicamba drift occurred in the Midsouth on numerous sensitive crops as a result of in-crop applications of the herbicide in dicamba-tolerant cotton and soybean varieties. In 2017 we broadened our website to include additional information directly addressing stewardship of dicamba and 2,4-D tolerant crop technology. We provided herbicide stewardship training for growers and other applicators, dealers, and Extension Agents for the past 3 years. Because producers, even with their best efforts, were having difficulty keeping dicamba within target fields, we began active laboratory and field research programs looking for answers. Proper herbicide stewardship will, no doubt, continue to be even more critical going forward. To help prepare future professionals we have incorporated herbicide stewardship training into our undergraduate and graduate curricula.

A SHORT COURSE ON HERBICIDE MODES OF ACTION AND HERBICIDE RESISTANCE. T. Mueller*; University of Tennessee, Knoxville, TN (117)

ABSTRACT

Weed control has faced many challenges over the years, and herbicides have greatly aided farmers and others in their efforts to reduce weed's negative effects. In broad acre crops, Glyphosate Resistant (GR) varieties have been commonly used in overly simple weed control regimes in soybeans, cotton, corn and other crops. The widespread occurrence of GR weeds has reduced the utility of GR crops, and has resulted in a renewed interest in alternate herbicide chemistries.

This poster details an educational short course to be held in 2019 that covers the various modes of action and also herbicide resistance to those various chemicals. Practical aspects of herbicide use and optimization of weed control strategies are important topics extensively covered in this course.

BURCUCUMBER MANAGEMENT IN PENNSYLVANIA: WHAT HAVE WE LEARNED IN 20 YEARS? D. Lingenfelter*[1], W. S. Curran[2]; [1]Penn State University, University Park, PA, [2]Penn State University, Bozeman, MT (118)

ABSTRACT

In the late 1990s, researchers at Penn State University conducted various experiments on burcucumber (*Sicyos angulatus*) biology and management. From these studies, certain herbicide options and tactics were recommended to farmers to help manage this problem weed in agronomic crops. Since then, not only does this weed continue to cause problems in crops but also, a few new herbicide active ingredients that might be effective on burcucumber have come to the market. Thus, no-till corn and soybean field studies were established in in 2018 in Pennsylvania (Landisville, Lancaster Co.) to evaluate PRE and POST herbicide programs containing these newer active ingredients as well as programs that were originally recommended. Studies were arranged in a randomized complete block design with three replications. Herbicides were applied with a small-plot, CO2-backpack sprayer system that delivered 15 GPA. In the corn trial, PRE herbicides were applied on May 7 and POST on June 8 when burcucumber seedlings were 1 to 4 inches tall. In the soybean study, a broadcast PRE application (s-metolachlor + metribuzin) was applied on May 15 and the POST treatments on June 20 when burcucumber was 2 to 18 inches tall (9 inch average height). Corn treatments included: atrazine, bicyclopyrone, bromoxynil, dicamba, fluthiacet, glufosinate, glyphosate, isoxaflutole, mesotrione, s-metolachlor, primisulfuron, prosulfuron, and tembotrione.

Primary POST soybean treatments included: chlorimuron, dicamba, fomesafen, glyphosate, imazethapyr, lactofen, and thifensulfuron. (Some of these combinations were used as premix formulations.) All the spray mixtures contained the necessary adjuvants. Visual weed control ratings were taken periodically throughout the growing season. In the corn study, all of the PRE treatments provided <84% burcucumber control prior to the POST application. Late season ratings showed that POST treatments containing atrazine, dicamba, glyphosate, primisulfuron, prosulfuron, and/or tembotrione provided 86-92% burcucumber control. The other POST treatments ranged from 67-81% control. In the soybean study, POST treatments containing chlorimuron, dicamba, and glyphosate provided 86-95% burcucumber control; while the others provided less control (73-84%). This preliminary study of newer herbicide options (e.g., bicyclopyrone, fluthiacet, glufosinate, mesotrione, etc.) suggests that these herbicides are not necessarily better than previously recommended products. Products that provide residual control such as atrazine, chlorimuron, primisulfuron, and prosulfuron continue to be effective herbicides for burcucumber management. Also, with the advent of dicamba-resistant soybean varieties, over-the-top applications of dicamba (especially if tank-mixed with chlorimuron) in soybean can help to improve control of burcucumber in this setting. The same principles of burcucumber management still apply today just as they did 20 years ago. The key points to burcucumber management include: i) avoid spreading the seed via harvest or tillage equipment; ii) use no-till practices to keep the seeds on the soil surface, thus allowing germination to occur over a shorter time period and reducing the number of germination flushes (this also improves herbicide effectiveness and performance); iii) plant shorter season corn varieties to allow earlier silage harvest (ensiling kills green/immature burcucumber seed); iv) use two-pass programs that include effective foliar and residual herbicides are required for season-long control; and v) pre-harvest burcucumber control is usually not effective. As newer herbicides or technologies come to the market, additional research will be necessary to determine their value in managing burcucumber.

GROWER PREFERRED EXTENSION TOPICS, INFORMATION SOURCES, AND DELIVERY METHODS IN VIRGINIA. K. B. Pittman*, M. L. Flessner; Virginia Tech, Blacksburg, VA (119)

ABSTRACT

The goal of cooperative extension is to help people use research-based knowledge to improve their lives, which is typically done through a combination of techniques such as face-to-face lectures, demonstrations, and written materials. To accomplish this goal, we need to know what information sources and delivery methods are the most likely to impact grower decisions. The objectives of these surveys were to determine what growers respond to in extension programming and if this varies between audience (row crop versus forage).

Two surveys, one given to those in the row crop community and another given to those involved in forage production were distributed in person and online between 2015 and 2017 at various extension meetings and field days in Virginia.While the overall surveys were different, both had similar questions regarding demographics and extension preferences. These questions pertained to information likely to influence a change in weed management practices (e.g. yield data, economic assessments, etc.), format preference for receiving information (e.g. extension presentations, social media, internet, etc.), primary source of information, and who has the largest impact when making herbicide-purchasing decisions (e.g. co-ops, neighbors, university extension, etc.). Data were first analyzed to determine if response could be pooled across survey by an ANOVA or a Chi-square test and then by response, either by means separation or summary statistics. Data were analyzed in JMP Pro 14.

Overall, there were 198 responses to the crop survey and 155 responses to the forage survey. All questions could be pooled across both surveys, indicating both audiences had the same preferences for information sources and delivery methods. Overall, respondents ranked economic impacts, weed control data, and yield as the most influential data to impact weed management decisions whereas on-farm demonstrations were ranked as the least influential way of impacting management decisions. Co-ops/suppliers/vendors, university extension and researchers, and crop consultants/advisors were the primary source of information and the most likely to make an impact on herbicide-purchasing decisions. Despite on-farm demonstrations being ranked as the least influential way to impact weed management decisions, it was ranked as one of the most preferred ways to receive information along with extension presentations and publications.

SCREENING FOR ALS-INHIBITOR RESISTANCE IN SHATTERCANE POPULATIONS COLLECTED FROM SORGHUM FIELDS IN TEXAS GULF COAST. S. Shrestha*[1], G. Hodnett[2], W. Rooney[2], M. V. Bagavathiannan[2]; [1]Mississippi State University, Starkville, MS, [2]Texas A&M University, College Station, TX (120)

ABSTRACT

Sorghum is among the top five cereal crops of the world with diverse use as human food, livestock feed and industrial feedstock. Shattercane, a weedy form of cultivated sorghum, is one of the common grass weeds found in sorghum production systems in the US. Herbicide-resistant grain sorghum technology (Inzen^{TM}) with resistance to the acetolactate synthase (ALS)-inhibitor nicosulfuron is expected to be available for commercial cultivation soon, but the current level of geographical distribution of shattercane and their sensitivity to ALS-inhibitor herbicides is unknown in parts of South Texas. Studies were conducted to 1) document the distribution of shattercane in sorghum production fields in the Texas Gulf Coast, and 2) assess their baseline sensitivity to the ALS-inhibitor herbicides nicosulfuron and imazethapyr. Shattercane was observed in sorghum production fields in the upper Gulf Coast region, with a frequency of approximately 20%. Thirty populations of shattercane collected during the survey were tested in the greenhouse for response to nicosulfuron and imazethapyr. All the shattercane populations were controlled by imazethapyr applied at the rate of 70 g a.i ha^{-1}. Nicosulfuron applied at the rate of 35 g a.i ha^{-1} controlled 28 populations, but the rest two survived the herbicide, with about 65% visual injury at 28 days after treatment. Dose-response experiments are in progress to determine the level of resistance in these populations. Findings will be helpful for promoting proactive measures for herbicide-resistance management in Inzen^{TM} sorghum technology.

[BMV1]Give a frequency estimate – for distribution

IMPROVING EARLY WEED DETECTION IN AN ERA OF RAPID RANGE EXPANSION THROUGH DEVELOPMENT OF A WEED ID NETWORK IN NY STATE. A. DiTommaso*, C. A. Marschner; Cornell University, Ithaca, NY (121)

ABSTRACT

While New York has formal diagnostic labs for insects and pathogens, a weed identification resource is lacking for the state. In addition, the mechanism for reporting invasive species locations has not been adopted by the agricultural community. A better understanding of the locations of problem weed species and populations would allow for more effective planning to contain and manage such weeds. Cornell's Weed Ecology and Management Lab is forming a network of extension educators and crop advisors to provide information on problem weeds so we can develop an map of where these weeds are in New York and identify new weeds as they arrive. In return, we will provide weed identification resources and diagnostic services for the grower communities our network serves. We are also working to establish a method for the

agricultural community to report priority and newly arrived weed species and biotypes, so that state agencies and growers can respond effectively to minimize impact on yields and profit.

COMPLICATED: KENTUCKY GROWER AND APPLICATOR IMPRESSIONS AND RESPONSES FOLLOWING 2018 DICAMBA TRAININGS. T. R. Legleiter*[1], J. Green[2]; [1]University of Kentucky, Princeton, KY, [2]University of Kentucky, Lexington, KY (122)

ABSTRACT

University of Kentucky Extension Weed Scientist conducted 14 trainings in 2017 to assist in meeting the EPA mandated dicamba training requirements for dicamba applications. An attendance of 1224 individuals was recorded at these University of Kentucky trainings. Immediately following 11 of the 14 trainings a live polling software was used to conduct a knowledge test of the audience of material that was presented. Eleven questions in total were asked of the audience and resulted in an average response rate of 35% of audience members. Audience members who participated answered the questions correctly at an average rate of 89% over the 11 sites in which the live polling was conducted. At the conclusion of the knowledge test the audience was asked to respond to the polling software with one word to describe how they felt about the dicamba tolerant soybean system. Following filtering and editing of multi-word responses, expletives, and non-word responses (emoji's) a total of 207 responses were collected. The highest occurring word was "complicated" at 17 occurrences, followed by "difficult", "exciting", "nervous", "scary", "sucks", "great", edited expletives, "scared", "needed", "interesting", and "risky" all occurring four or more times. This exercise of asking for applicator and grower responses to the dicamba system revealed a large range of emotions and feelings about this technology, but overwhelmingly indicated it was complicated.

AN INTERACTIVE WEB APP THAT ESTIMATES THE RISK OF DEVELOPING HERBICIDE RESISTANCE. A. Kniss*[1], A. T. Adjesiwor[1], N. C. Lawrence[2]; [1]University of Wyoming, Laramie, WY, [2]University of Nebraska-Lincoln, Pullman, WA (123)

ABSTRACT

Using effective herbicide mixtures has been shown in previous research to significantly delay resistant weeds, and is among the most important decisions farmers can make with respect to herbicide resistant weed management. However, it can be difficult to determine which herbicide combinations will both provide effective broad-spectrum weed control while also providing effective proactive resistance management. We developed a web application that qualitatively estimates the risk of herbicide resistant weed evolution based on herbicide programs entered by the user. The model was coded in the R programming language, and a web interface was added using the shiny development environment. The app has a user-friendly interface that allows farmers, agronomists, or researchers to select the crops and herbicide programs they plan to use over a 4 year period, then estimates a herbicide resistance risk score for each herbicide site of action chosen. Herbicide efficacy data was estimated from a variety of sources for single site of action (SOA) herbicides registered for use in sugarbeet, corn, dry bean, small grains, and soybean. We included only single SOA herbicides in this initial version of the app to simplify efficacy calculations.

Because evolution of herbicide resistance is a multi-year process, the model requires users to choose crops and herbicide programs for a 4 year period before it will provide risk estimates. Once herbicides are chosen for all four years, and a weed species is selected, then the model will calculate a herbicide resistance risk score for each herbicide SOA that was selected. Risk scores are currently on a scale of 0 to 4. The minimum score of 0 means the herbicide site of action was never used during the four year period. Each time an effective SOA is used on the target weed, that SOA is initially given a score of 1; however, this score is reduced if a second effective SOA is applied in the same year. If a SOA is selected each of the four years, and in all four years there was no effective second SOA selected, this would result in the maximum risk score of 4. The risk score for each SOA within a year is reduced by an amount that depends on the efficacy of the second SOA. If the second SOA provides equal or greater control of the target weed, the risk score fro that year is reduced to 0.1. If the second SOA provides less than 60% control of the target weed, then the risk score for the first SOA is not reduced for that year. From a practical resistance management perspective, the goal when selecting herbicides should be to keep the total four-year risk score below 1.0. To do this, the user must ensure that each time a herbicide site of action is used, it is combined with a second herbicide that is also effective on the target weed. A four-year risk value less than 1 indicates a SOA was never used without a second effective site of action, and therefore, the risk of resistance is relatively low. At this time, the risk scores calculated by the model should be considered qualitative – that is, a risk score value of 0.5 is not necessarily twice as likely to select for resistance as a risk score of 0.25. Although providing quantitative risk estimates is an eventual goal as we continue to develop this model, there are numerous other factors (such as application timing, weed biology, and herbicide chemistry) that must be quantified and incorporated to reach that goal. In its current form, the model simply determines 'high' risk (values greater than 1) vs. 'less' risk based on the use of multiple sites of action.

The application can currently be accessed at the following URL: https://wyoweeds.shinyapps.io/HerbicideRiskCalculator/

DICAMBA VOLATILITY FROM NITROGEN FERTILIZER ENRICHED SOILS. M. Bernards*, B. S. Heaton; Western Illinois University, Macomb, IL (124)

ABSTRACT

HORDEUM SPP. AND *BROMUS* SPP. WITH GLYPHOSATE RESISTANCE, AS A NEW INFECTION CASE IN OLIVE GROVE FROM SOUTH OF SPAIN. C. Palma-Bautista[1], A. M. Rojano-Delgado[2], D. A. Mora[2], R. Domínguez-Mendez[2], J. M. Rosario[3], J. Vasquez-Garcia[2], J. Portugal[4], R. De Prado Amian*[5]; [1]University of Cordoba, CÓRDOBA, Spain, [2]University of Cordoba, Cordoba, Spain, [3]Universidad Católica Tecnológica del Cibao, La Vega, Dominican Republic, [4]Polytechnic Institute of Beja, Beja, Portugal, [5]University of Cordoba, Córdoba, Spain (125)

ABSTRACT

Glyphosate [N-(phosphonomethyl)-glycine] is the world's most successful post-emergence and non-selective herbicide. In Southern Spain, it has been widely used to control weeds in citrus groves, olive groves, grape vineyards, and other perennial and annual crops, as well as in path borders, railway lines, recreation areas and derelict sites. This herbicide is absorbed through leaves and other young-green tissues, as well as translocated via phloem into meristematic tissues. Glyphosate is a potent inhibitor of 5-enolpyruvylshikimate 3-phosphate synthase (EPSPS) by blocking the biosynthesis of phenylalanine, tryptophan, tyrosine and other aromatic compounds in susceptible plants.Glyphosate-resistant weeds are able to survive glyphosate exposure due to target-site (mutations in the gene encoding the EPSPS or gene duplication) or

non-target-site (degradation to non-toxic compound, impaired translocation, poor absorption and/or vacuolar compartmentation) resistance mechanisms, alone or in association. Since the appearance of a *Conyza bonariensis* resistant to glyphosate in 1999, five other biotypes (*C. canadensis, C. sumatrensis, L. rigidum, L. multiflorum* and *L. perenne*) have been confirmed and all of them have been widely studied. During the last two years farmers and technicians have begun to complain about the appearance of new species that are not controlled at higher recommended glyphosate doses (1080 g ae ha^{-1}). These two grasses, belonging to the genus *Bromus* and *Hordeum*, have been detected in almond and olive grove crops in Southern Spain.

Greenhouse trials conducted on 18 populations collected in olive and almond groves from *Bromus rubens* and 8 populations of *Hordeum murinum* showed that at field doses of glyphosate (1000 g ae ha^{-1}) the plants survived 28 days after application. On the other hand, the GR_{50} values (dose of herbicide necessary to reduce fresh weight to 50% with respect to the control) ranged between 300 to 900 for *B. rubens* and between 300 to 600 g ae ha^{-1} for *H. murinum*. Future studies on the possible mechanisms involved will allow us to know if we are facing a natural tolerance or resistance to glyphosate.

INFLUENCE OF CYP450 IN THE RESISTANCE TO PPO-INHIBITING HERBICIDES: CASE OF A *EUPHORBIA HETEROPHYLLA* BIOTYPE. A. M. Rojano-Delgado[1], C. Palma-Bautista[2], J. Vazquez-Garcia[1], D. A. Mora[1], J. M. Rosario[3], J. Portugal[4], R. De Prado Amian*[5]; [1]University of Cordoba, Cordoba, Spain, [2]University of Cordoba, CÓRDOBA, Spain, [3]Universidad Católica Tecnológica del Cibao, La Vega, Dominican Republic, [4]Polytechnic Institute of Beja, Beja, Portugal, [5]University of Cordoba, Córdoba, Spain (126)

ABSTRACT

The CyP450 is a superfamily which is envolved in resistance evolution due to P450-catalyzed enhanced rates of herbicide metabolism. Its inhibition, not only affects the metabolism but also produces a series of chain effects that can be observed through other parameters. To determine the relationship between the CyP450 inhibition and the protoporphyrin (proto) XI levels (biochemical parameter that indicates the PPO-inhibiting herbicides resistance), two biotypes of *Euphorbia heterophylla* were treated with fomesafen (diphenyl ether) at 250 g ai ha-^{1} and different CyP450 inhibitors (malathion, PBO and amitrol). A biotype of *Euphorbia heterophylla* with cross resistance to PPO-inhibiting herbicides and fomesafen metabolism, among other resistance mechanisms (EuR-4) was one of them. The other biotype was susceptible to PPO-inhibiting herbicides (EuS). The obtained proto IX levels, without CyP450 inhibitors, for EuR-4 and EuS biotypes supported the known ED_{50} values (7234.5 and 12.27 g ai ha^{-1}, respectively), being the proto IX accumulation in EuR-4 biotype less than in the EuS biotype (0.633 respect to 12.081 nmol g^{-1} fresh weight). So for EuR-4 biotype with malathion, PBO and amitrol, the proto IX accumulation values were 1.934, 4.527 and 7.926 nmol g^{-1} fresh weight, respectively, being clearly higher than only with fomesafen without an inhibitor (0.633 nmol g^{-1} fresh weight). While for the EuS biotype those values with the inhibitors were 13.233, 12.991 and 14.096 nmol g^{-1} fresh weight, respectively, which were very different from that obtained with fomesafen without an inhibitor (12.081 nmol g^{-1} fresh weight). When the CyP450 inhibitors were applied, those proto IX values increased, but lower than the EuR-4 biotype, since it does not have any involved resistance mechanisms. The proto IX tests suggest the presence of a strong bond between the CyP450 system and the resistance in the case of the EuR-4 biotype. Although more studies are needed with other PPO-inhibiting herbicides to confirm if this enzymatic system is the cause of the cross resistance to PPO-inhibiting herbicides in the EuR-4 biotype.

MULTIPLE RESISTANCE TO IMI AND FOP HERBICIDES OF *L. RIGIDUM* BIOTYPES FOUND IN CLEARFIELD WHEAT CROPS. R. Domínguez-Mendez[1], C. Palma-Bautista[2], A. M. Rojano-Delgado[1], J. M. Rosario[3], M. D. Osuna[4], J. Portugal[5], R. De Prado Amian*[6]; [1]University of Cordoba, Cordoba, Spain, [2]University of Cordoba, CÓRDOBA, Spain, [3]Universidad Católica Tecnológica del Cibao, La Vega, Dominican Republic, [4]Agrarian Research Center "Finca La Orden Valdesequera", Badajoz, Spain, [5]Polytechnic Institute of Beja, Beja, Portugal, [6]University of Cordoba, Córdoba, Spain (127)

ABSTRACT

Weed control in wheat is one of the main objectives of farmers to obtain higher yields. Due to the repercussion of weed resistance to herbicides in this crop, detecting and identifying the resistant species and how to control them are important, especially when the resistance is multiple. In this work, a *Lolium rigidum* population (R) with suspected multiple resistance to imazamox and diclofop-methyl, was studied. This R population was always compared with a susceptible population (S) to these herbicides. For that, the herbicide dose-reponse and enzymatic activity assays were carried out. The dose-response assays showed that the R population was 19.85 and 21.20 times more resistant to imazamox and diclofop-methyl, respectively, than the S population. The same response was observed in the enzymatic activity assays, where the I_{50} values (herbicide concentration that reduces the enzymatic activity by 50%) for the R population were 398.46 and 134.14 μM, while the values for the S population were 3.42 and 29.91 μM for imazamox and diclofop-methyl, respectively.

The above results confirmed that the R population is multiple resistant to imazamox and diclofop-methyl. In addition, possible mutations in the ALS and ACCase genes can also be involved in the multiple resistance to these herbicides as can be observed in the enzymatic activity results.

More studies are needed to know all the involved resistance mechanisms in this R population.

TRICOTYLEDENOUS GIANT RAGWEED (*AMBROSIA TRIFIDA* L.). E. R. Page*[1], S. Meloche[2], J. Bae[3], J. Larsen[2], M. Laforest[4], R. E. Nurse[1]; [1]Agriculture and Agri-Food Canada, Harrow, ON, [2]Agriculture and Agr-Food Canada, Harrow, ON, [3]Agriculture and Agri-Food Canada, Harrow, BC, [4]Agriculture and AgriFood Canada, St-jean-sur-Richelieu, QC (128)

ABSTRACT

Giant ragweed (*Ambrosia trifida* L.) is an annual monocarpic weed species that is native to North America. As a seedling, giant ragweed's most notable characteristic are its palmately lobed leaves that are initially oppositely arranged but frequently become alternate further up the main stem at later stages of development. While giant ragweed leaves most often have 3-5 lobes, there is a great deal of phenotypic plasticity that results in leaves with any number of lobes ranging from 0-5. Similarly, giant ragweed is most often classified as a dicotyledenous species, however as reported herein, there is also plasticity in cotyledon number and a tricotyledynous individual has been observed. The objective of the following communication is to describe and provide evidence for this unique phenotype and to discuss possible mechanisms underlying its phenology and physiology.

AN ALA$_{122}$THR SUBSTITUTION IN THE AHAS/ALS GENE CONFERS IMAZAMOX-RESISTANCE IN JOINTED GOATGRASS (*AEGILOPS CYLINDRICA* HOST.). I. C. Burke*, J. Rodriguez, A. Hauvermale, A. Carter; Washington State University, Pullman, WA (129)

ABSTRACT

Jointed goatgrass (*Aegilops cylindrica* Host) is a troublesome weed infesting western United States wheat production areas. As jointed goatgrass is closely related to wheat, there are only two herbicides that are effective for management. Both imazamox and mesosulfuron inhibit acetohydroxyacid synthase/acetolactate synthase (AHAS/ALS). In 2015, a suspected imazamox resistant biotype of jointed goatgrass was found in eastern Washington. In an effort to understand the mechanism of resistance, mesosulfuron and imazamox were applied to the suspected resistant and susceptible jointed goatgrass biotypes in increasing concentrations to evaluate dose response as a function of biomass reduction. The resulting dose-response data were fit using a 3-parameter log-logistic with GR_{50} (50% growth reduction) as one of the parameters. Mesosulfuron controlled 100% of the susceptible biotype at the lowest application rate of 150 mg ai ha^{-1}, whereas the resistant biotype had a GR_{50} of 21.7 g ai ha^{-1}. Likewise, when treated with imazamox, the resistant biotype had a GR_{50} of 308 g ai ha^{-1}, which was 4,400 times more resistant to the known susceptible biotype with a GR50 of 70 mg ai ha^{-1}. Sequencing of the ALS gene did not identify a Ser_{653} mutation that would be indicative of a cross with Clearfield wheat. Instead, an Ala_{122}Thr substitution in the herbicide binding region of the ALS gene on the D-genome of the resistant goatgrass biotype was discovered that co-segregated with the resistant phenotype. The newly discovered Ala_{122}Thr substitution on the D genome in the resistant goatgrass biotype appears to confer a high level of resistance to imazamox, and may also confer cross resistance to mesosulfuron.

MODELING SEED GERMINATION IN PALMER AMARANTH (*AMARANTHUS PALMERI*). M. Matzrafi*, S. Ohadi, M. B. Mesgaran; University of California, Davis, Davis, CA (130)

ABSTRACT

The environmental conditions under which parental plants are reared can affect the seed germination characteristics of the progeny population. The variation originating from such maternal effects has rarely been incorporated into models of seed germination. Here, using Palmer amaranth (*Amaranthus palmeri* S. Watson) as a model system we tested the effects of drought during the growth of parental plants on parameters of a hydrotime model of progeny seeds. We grew two populations (from California and Kansas) under continues water-deficit (WD) or well-watered (WW) conditions. Plants of both populations from each treatment were isolated and maintained in different greenhouses when reached the reproductive stage and their seeds were collected for germination assays. Both parental and progeny seeds were subject to five water potentials (0, -0.2, -0.4, -0.6 and -0.8 MPa), incubated at 30°C, and germination was monitored daily. In both tested populations, seeds originating from plants grown under water stress were less dormant than those obtained from plants grown under normal watering conditions. The estimated median base water potential, i.e. the water potential at which 50% of seeds cannot germinate, was more negative for seeds from water-stressed than for seeds of well-watered parents or the original parental seeds. Our results show that Palmer amaranth plants experiencing drouth during their growth can produce less dormant seeds that are more water stress tolerant and hence can germinate from drier soils.

SEED BANKS DURING FIVE YEAR ON INTEGRATED CROP-LIVESTOCK-FOREST SYSTEM UNDER DIFFERENT SHADING LEVELS IN SINOP, MATO GROSSO, BRAZIL. F. S. Ikeda*[1], S. D. Cavalieri[1], F. Poltronieri[2], L. Menegatti[2], F. M. Lima Júnior[2], L. H. Metz[2], B. T. Fonseca[2]; [1]Embrapa, Sinop, Brazil, [2]Federal University of Mato Grosso, Sinop, Brazil (131)

ABSTRACT

SEED BANKS SIZE DURING SIX YEARS ON SINGLE AND INTEGRATED CROPPING SYSTEMS IN SINOP, MATO GROSSO, BRAZIL. F. S. Ikeda*[1], S. D. Cavalieri[1], F. Poltronieri[2], L. Menegatti[2], F. M. Lima Júnior[2], L. H. Metz[2], B. T. Fonseca[2]; [1]Embrapa, Sinop, Brazil, [2]Federal University of Mato Grosso, Sinop, Brazil (132)

ABSTRACT

THE INTERACTION BETWEEN COVER CROPS AND HERBICIDE PROGRAMS ON WEED MANAGEMENT IN TOBACCO. E. Haramoto*[1], C. J. Lowry[2], R. Pearce[1]; [1]University of Kentucky, Lexington, KY, [2]Agricultural Research Service, Urbana, IL (133)

ABSTRACT

Cover crops play an important role for Kentucky's tobacco producers—they provide ground cover to reduce soil erosion and, especially in combination with strip-tillage, contribute to weed management. This study sought to examine the interaction between common tobacco herbicides and cover crop mixtures (wheat plus crimson clover and cereal rye plus crimson clover) to determine whether (1) the herbicides affect establishment and growth of the cover crops and (2) the cover crops, with and without different herbicide programs, contribute to tobacco weed management. Two rates of sulfentrazone plus carfentrazone-ethyl (0.5X and 1X, applied PRE) were examined; the 1X rate was also combined with clomazone (applied POST) or pendamethalin (applied PRE). A weedy control was also included (no herbicides used), as was a hand-weeded weed-free control (no herbicides used, no weeds present in tobacco). Tobacco was planted in 2016 and weed management treatments were imposed; cover crops were planted after tobacco harvest in Fall 2016. A fallow treatment was also included. Following cover crop termination in Spring 2017, tobacco was planted into the same plots, the same weed management treatments were used, and the whole cycle was repeated an additional year. Cover crop density was not affected by the herbicides, though biomass of crimson clover was reduced in the weedy plots in one year suggesting that summer annual weed residue interfered with successful biomass accumulation. Cereal rye reduced weed biomass within tobacco in 2017, but we found no effect of cover crop in 2018. Herbicide effects on weed density and biomass within tobacco were independent of cover crop effects. Overall, we found the greatest suppression of both weed density (including grasses and broadleaves) and biomass with the 1X rate of sulfentrazone plus carfentrazone-ethyl used in combination with either clomazone or pendimethalin. Weed community composition also differed depending on whether plots received herbicides, though no differences between cover crop treatments were detected. Tobacco yield in 2017 was not affected by the cover crops (yield data from 2018 not yet available). While current herbicide labels may be either vague in language related to cover crops or caution that stand reductions may occur, these results suggest that the products tested will not interfere with wheat, cereal rye, or crimson clover establishment. However, more work is needed to determine whether these results can be extrapolated to other environmental conditions and soil types. While cover crops did not provide weed control in the absence of herbicides, our results suggest that incorporating cover crops and strip tillage into tobacco production will not reduce yield or sacrifice weed management provided by common herbicide products.

ADAPTATION OF PALMER AMARANTH TO THE UPPER MIDWEST. M. Coura Oliveira*[1], M. Bernards[2], A. J. Jhala[3], C. Proctor[3], S. Stepanovic[4], R. Werle[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]Western Illinois University, Macomb, IL, [3]University of Nebraska-Lincoln, Lincoln, NE, [4]University of Nebraska-Lincoln, Grant, NE (134)

ABSTRACT

Palmer amaranth (*Amaranthus palmeri*) is ranked as the most troublesome weed species in the southern United States. In recent years, Palmer amaranth has become more predominant in the southern part of the Midwest United States, further increasing the complexity of weed management in corn and soybean production systems. However, Palmer amaranth adaptation to the upper Midwestern states such as Wisconsin is uncertain. The objective of this study was to evaluate the adaptation of Palmer amaranth to different cropping systems (corn, soybeans and fallow) across a range of US Midwest climates. A Palmer amaranth population from Grant, Nebraska collected from a soybean field in the fall of 2017 was used as the source population for the study. The study was conducted in five locations: Grant, Clay Center, and Lincoln, Nebraska; Macomb, Illinois; and Arlington, Wisconsin, simulating southwest-to-northeast dissemination of the species. At each location, crops (corn and soybean) were planted in May following locally adopted practices. Palmer amaranth plants were started under greenhouse conditions and transplanted to the field at the 2-3 leaf stage (5 to 8 cm in height) in all locations. To simulate early- and late-emerging cohorts, Palmer amaranth seedlings were transplanted at two timings, early June and early July to soybean, corn, and fallow blocks in the same field. Twenty-four Palmer amaranth seedlings were equidistantly placed (0.76 m apart) between rows within each cropping system. Palmer amaranth plants were harvested at or after flowering (methodology varied across locations) and the gender and biomass (dry matter) of each individual plant recorded. Palmer amaranth gender and biomass were analyzed with chi-squared and ANOVA in R, respectively. Results across locations, transplanting time, and cropping-systems indicate that the gender ratio in Palmer amaranth did not deviate from the expected 50:50 (male:female) ratio ($P > 0.05$). In general, Palmer amaranth produced higher biomass when growing in fallow, followed by soybean and corn, except in Grant in the June transplanting time, where Palmer amaranth biomass in fallow was similar to soybean. The highest and lowest Palmer amaranth biomass detected in this study were 302.7 g (June transplanting time, fallow, Macomb, IL) and 1.6 g (July transplanting time, corn, Arlington, WI), respectively. Our results indicate that the expected male:female ratio in Palmer amaranth is 50:50. Palmer amaranth growth was influenced by location, emergence time and crop canopy type. Palmer amaranth was able to produce a large amount of biomass in the northernmost site particularly when early transplanted and under fallow or less competitive crop canopy (soybean), indicating that if seeds are introduced, Palmer amaranth will likely thrive in the upper Midwest.

EFFECT OF COVER CROP BIOMASS ON THE SUMMER ANNUAL WEED DENSITY AND BIOMASS IN SOYBEAN. T. Stanton*, E. Haramoto; University of Kentucky, Lexington, KY (135)

ABSTRACT

Cover crop residue can contribute to season long control of weeds but achieving the necessary cover crop biomass may cause other complications. Often to reach the threshold for season long control, cover crops need to be terminated later which may cause delays in cash crop planting. Once terminated, high residue can lead to poor cash crop stand if planters are not set correctly. Studies have found either linear or exponential relationship between cover crop biomass and weed abundance suggesting that even low amounts of cover crop biomass will reduce weed density. A study was conducted in Lexington, KY, to determine if there is a quantitative relationship between lower cover crop biomass amounts (i.e., 0-500 g m^{-2}) and summer annual weed density and biomass in the following soybean crop that also received herbicides for weed control. The previous fall two cover crop species (rye and wheat) were established using several methods resulting in a range of various cover crop biomass in the spring. Cover crops were terminated with glyphosate and soybeans were planted 2-5 weeks after termination. Fomesafen, an herbicide with some residual activity, was applied immediately after planting (PRE); a portion of each plot did not receive the PRE application to determine the impact of the cover crop residue alone and potential interactive effects with the herbicide. Weed density was measured after the PRE and again prior to a POST herbicide treatment. Soybean stand count, yield, and biomass accumulation between stages R1 and R5 were also measured. In all 3 years, weed density was higher prior to the POST application than after the PRE application. In 2018, there was a significant linear relationship with a negative slope between spring cover crop biomass and weed density after the PRE and prior to the POST herbicide applications. In other years, however, this relationship was not significant. The relationship between cover crop biomass and weed density in the unsprayed areas did not differ from the sprayed portion of the plots, though weed density was higher in the former compared to the latter. Soybean stand count was reduced with increasing wheat biomass but not rye biomass in one year. Soybean biomass accumulation between R1-R5 and soybean yield were not impacted by cover crop biomass or species. Within the range of cover crop biomass amounts used in this study, under 500 g m^{-2}, increasing biomass may help reduce weed density however the effect was not consistent across years. This effect was consistent where fomesafen was and was not applied; while density was lower in areas that received fomesafen application compared to areas that did not, the cover crop residue did not interfere with the application nor provide additional suppression. Soybean stand was reduced in one year as the amount of residue increased but, likely due to soybean's ability to compensate, this did not result in yield reductions in the current trial.

GERMINATION ECOLOGY OF CARPETWEED, CAROLINA GERANIUM, ECLIPTA, AND GOOSEGRASS. S. M. Sharpe*[1], N. Boyd[2]; [1]University of Florida, Wimauma, FL, [2]University of Florida, Balm, FL (136)

ABSTRACT

Florida vegetable production row middle weed management is challenging and often requires several herbicide applications. Aligning POST herbicide sprays with weed emergence and a susceptible growth stage should increase herbicide efficacy and control. Adaptation of emergence models to sub-tropical climates is complex compared to temperate climates since at the biofix date, temperatures are higher than the base temperature. Reductionist considerations into seed ecology, namely germination and dormancy, are required for such adaptations. The objective of the study was to examine the impact of temperature and osmotic potential on Carolina geranium (*Geranium carolinianum* L.), goosegrass (*Eleusine indica* L.), eclipta [*Eclipta prostrata* (L.) L.], and carpetweed (*Mollugo verticillata* L.). Carpetweed seed germination increased with high temperatures (≥ 35 C), fluctuating tempreatures (35/20 and 35/25 C), occurred as low as -0.5 MPa, and was positively photoblastic. Carolina geranium seed germinated in both light and darkness, at temperatures between 10 and 20 C, and as low as -0.4 MPa. Eclipta optimal seed germination occurred between 15 and 25 C, as low as -1 MPa, and was positively photoblastic. Goosegrass peak seed germination occurred at 35 C, occurred as low as -0.5 MPa, and was demonstrated some degree of positive photoblasticity. Species specific seed ecology results provides the necessary insights for developing ecology-based growing degree-day accounting restrictions for field emergence modelling.

DO PESTICIDE SEED TREATMENTS ALTER THE ABUNDANCE AND COMPOSITION OF WEED COMMUNITIES? R. G. Smith*, S. A. Palmer, N. D. Warren; University of New Hampshire, Durham, NH (137)

ABSTRACT

Use of pesticide seed treatments (coating seeds with insecticides and/or fungicides, hereafter "PST") is common in conventional maize and soybean production. Despite their widespread use, however, little is known about how PST may affect the natural enemies of weeds, and hence, weed population dynamics. We are currently conducting a four-year field experiment in southeastern New Hampshire in which identical genotypes of maize and soybean are planted in rotation with and without pesticide seed treatments under three tillage systems (full-till, strip-till, and no-till). Each year we quantify the germinable weed seed bank and aboveground weed community responses to these treatments (as well as natural enemy populations and weed seed predation). Based on our previous research we hypothesize that PST alter the abundance of natural enemies (e.g., soil-dwelling seed predators and pathogens) that damage or destroy weed seeds in the soil, and therefore weed populations in treated plots will differ from those in treatments without PST. Additionally, we expect that the effects of PST may vary across tillage systems. Based on our preliminary analyses (ANOVA and multivariate approaches) of the weed seed bank and aboveground weed community data from the first two years of the experiment, there is little evidence to suggest that PST has consistent directional effects on weed populations. This research is ongoing, however, and additional data may alter these preliminary conclusions.

RELATIONSHIP BETWEEN THE GROWTH HABIT AND THE VEGETATIVE AND REPRODUCTIVE AERIAL STRUCTURES OF JUNGLERICE (*ECHINOCHLOA COLONA*). G. Picapietra[1], H. A. Acciaresi*[2]; [1]EEA INTA Pergamino, Argentina, Argentina, [2]Instituto Nacional Tecnologia Agropecuaria, Pergamino, Argentina (138)

ABSTRACT

Junglerice is one of the most important spring-summer weed in central pampean region of Argentina. Seedling emergence occur from September to January under field conditions, and according to the growth environment may show changes in vegetative and reproductive structures, although some authors have observed a poor phenotypic plasticity trough different densities of planting. An experiment was carried out in Pergamino, Argentina, to determine the effect of density and growth habit on vegetative and reproductive aerial structures. Four meters-squared plots with five-repetitions were delimited for each three density levels to each year of study: 2, 156 and 300 pl.m^{-2}; 4, 45 and 250 pl.m^{-2}; 0.25, 35 and 260 pl.m^{-2} in the years 2014, 2015 and 2016, respectively. When the plant took maturity and before seed dispersal, the height and diameter of each plant were measured and the growth habit was characterized: erect (E), semi-prostrate (SP) or prostrate (P). Later, the number of stems with panicle was counted, the weight of a thousand grains and the aboveground dry matter was determined, and plant yield was calculated. The data were subjected to an unbalanced ANOVA and comparison of means through the LSD test ($\alpha = 0.05$) in the statistical software Infostat. In order to fulfill the assumptions of the analysis, the variables density, height and diameter were standardized and then transformed through the arc sine of the root; aerial dry matter, number of stems, weight of thousand and yield were transformed by the logarithm. Growth habit and density were strongly related, where an isolated plant in 4 m^2 was completely prostrate, 2-4 pl.m^{-2} were semi-prostrate and densities above 35 pl.m^{-2} has fully erect growth. The decreasing ranking was E >> SP> P for plant height, P> SP >> E for the diameter, P >> SP> E for stems number, P >> SP> E for aboveground dry matter and the grain yield was P> SP> E, while the seeds weight showed no significant differences. This results show that *E. colona* has a broad morphological plasticity characterized according to the habit of growth and determined by density. Except for grain yield, all measured variables were significant for each growth habit.

THE MITOCHONDRIAL GENOME OF GOOSEGRASS (*ELEUSINE INDICA*) AND A METHOD FOR DETECTING MITOCHONDRIAL GENE CONTENT IN SPECIES LACKING ASSEMBLED MITOCHONDRIAL GENOMES. N. D. Hall*[1], H. Zhang[1], J. P. Mower[2], L. R. Goertzen[1], J. S. McElroy[1]; [1]Auburn University, Auburn, AL, [2]University of Nebraska–Lincoln, Auburn, NE (139)

ABSTRACT

The assembled mitochondrial genome for Eleusine indica (goosegrass) provides baseline genomic data for an economically significant invasive species that is also the maternal parent of the allotetraploid crop African finger millet (Eleusine coracana). The assembled genome is the product of various-length libraries; it contains 33 protein coding genes, 6 rRNA subunits, 24 tRNA, 8 large repetitive regions, with 5 that are actively recombinogenic, and 15 kp of transposable elements across a total of 520,691 bp. The E. indica mitochondrial genome shows evidence of RNA editing and has lost rpl2, rpl5, rps14, rps11, sdh4 and sdh3 genes, consistent with a pattern that is widespread among Poaceae. Examination of additional mitochondrial coding sequences from Poaceae and an in silico Southern blot approach show high sequence conservation and provide new data on mitochondrial gene loss patterns within Poaceae.

CAN POLLINATION BAGS BE USED TO EVALUATE THE SEED PRODUCTION OF COMMON RAGWEED (*AMBROSIA ARTEMISIIFOLIA*)? M. Simard*[1], R. E. Nurse[2], E. R. Page[2]; [1]Agriculture and Agri-Food Canada, Saint-jean-sur-Richelieu, QC, [2]Agriculture and Agri-Food Canada, Harrow, ON (140)

ABSTRACT

Knowing if and when seeds are shattered is essential before any late season weed management can be envisioned to limit weed seed return to the soil. To evaluate seed dispersal (shattering), seed traps are usually laid out on the soil surface or at different heights around a single or multiple plants and dispersed seeds are collected to give an area-based assessment. Mesh (pollination) bags attached on plants after the flowering period are easy to install, cheap and give an individual plant based evaluation of seed production. However, invertebrate seed predators trapped inside the bag or microclimatic conditions could modify seed formation or viability in bags. To evaluate the effect of these bags on common ragweed (*Ambrosia artemisiifolia*) seed production, a total of 32 ragweed plants were grown (in a corn crop and in an open field) and each plant was randomly assigned an open (staked) or closed bag. When the corn crop was ready to harvest, all ragweed plants were collected. For each plant, seeds retained (on the plant) and dispersed (in each bag) were collected, weighed and counted. Seed quality was also evaluated (signs of seed predation, emptiness and viability). Although the percentage of viable seeds collected in closed bags was lower (by less than 10%), the total number and biomass of viable seeds collected in closed bags vas higher or equivalent.

EMERGENCE CHARACTERISTICS OF PALMER AMARANTH POPULATIONS FROM THE U.S. CENTRAL GREAT PLAINS. R. Liu*[1], V. Kumar[1], T. Lambert[2], M. Manuchehri[3], N. C. Lawrence[4], M. V. Bagavathiannan[5], T. Gaines[6]; [1]Kansas State University, Hays, KS, [2]Kansas State University, hays, KS, [3]Oklahoma State University, Stillwater, OK, [4]University of Nebraska-Lincoln, Pullman, WA, [5]Texas A&M University, College Station, TX, [6]Colorado State University, Fort Collins, CO (141)

ABSTRACT

The widespread occurrence of multiple herbicide-resistant Palmer amaranth warrants the development of integrated strategies for its control in the Central Great Plains (CGP), including Kansas. To develop any effective control strategy, an improved understanding on emergence characteristics of Palmer amaranth populations from the region is needed. To fulfill this research gap, a field study was initiated at Kansas State University Agricultural Research Center near Hays, KS in 2018. Nine Palmer amaranth populations collected from Colorado (CO1, CO2), Oklahoma (OK), Kansas (KS1, KS2), Texas (TX), Nebraska (NE1, NE2, NE3) were included. The study was

performed in a randomized complete block design, with 4 replications. Two hundred seeds from each selected population were uniformly sown on soil surface inside an open-ended cylindrical PVC rings (30-cm dia) on March 30, 2018. The number of emerged seedlings were counted and removed on weekly basis util the cessation of any further emergence (April 29 through August 30). Cumulative emergence was calculated based on the percentage of total emergence during the growing season. The cumulative emergence data were fitted by using a 3- parameter log-logistic regression model. Cumulative growing degree days (cGDD, T_{base} 16.6 C) were used to predict the Palmer amaranth emergence. Among all populations, CO1 emerged earlier, with a minimum of 3 cGDD required for 10% (E_{10} value), 19 cGDD required for 50% (E_{50} value), and 112 cGDD required for 90% (E_{90} value) cumulative emergence. In contrast, the seedlings emergence of OK and TX populations was delayed, with 20 to 30 cGDD required for 10%, and 68 to 79 cGDD required for 50% cumulative emergence. Lower negative values of *b* parameter for OK (-2.2) and TX (-1.8) populations further indicated their lower emergence rates (slower in dormancy release) as compared to other populations. No significant differences in the cGDD required for 90% cumulative emergence were observed among all the populations. These preliminary results suggest the existence of differential emergence characteristics among Palmer amaranth populations from the CGP region. Growers should adopt site-specific and multi-tactic tools to manage the Palmer amaranth seedbanks on their production fields.

A NEW MUTATION IN THE *AMARANTHUS RETROFLEXUS* ACETOLACTATE SYNTHASE GENE CONFERS RESISTANCE TO IMIDAZOLINONES, BUT NOT SULFONYLUREAS AND TRIAZOLOPYRIMIDINES. M. Laforest*[1], B. Soufiane[2], K. Bisaillon[2]; [1]Agriculture and AgriFood Canada, St-jean-sur-Richelieu, QC, [2]Agriculture and AgriFood Canada, St-Jean-sur-Richelieu, QC (142)

ABSTRACT

Martin Laforest, Brahim Soufiane, Katherine Bisaillon, Eric Page, Robert Nurse and Marie-Josée Simard

Many different cases of herbicide resistant amaranths have been reported in the past. For example, six mutations conferring resistance to group 2 (WSSA) herbicides have been reported for *Amaranthus retroflexus* L. In the summer of 2016, a case of potentially herbicide resistant redroot pigweed was reported in Saint-Louis-de-Gonzague (Qc, Canada) in an identity preserved soybean field. Dual II Magnum™ (s-metolachlor/benoxacor), Pursuit™ (imazethapyr) and Classic™ (chlorimuron ethyl) were applied PRE. Samples from that field were collected and analysed to characterize the mechanism and level of resistance. Sequencing of the acetolactate synthase gene revealed that none of the previously known mutations were present. The new mutation identified causes a serine to asparagine substitution at amino acid 653. Dose response experiments indicated a resistance factor of 40 for imidazolinones (imazethapyr) but susceptibility to sulfonylureas (chlorimuron ehtyl) and triazolopyrimidines (flumetsulam). To promptly provide producers with information about resistance resulting from this mutation, a quick genetic test was developed and validated.

CHANGES IN RICE FIELD ALGAE ASSEMBLAGE IN RESPONSE TO FERTILIZER APPLICATION RATE. S. Ohadi*[1], J. D. Madsen[2], K. Al-Khatib[1]; [1]University of California, Davis, Davis, CA, [2]USDA-ARS, Woodland, CA (143)

ABSTRACT

California rice production is challenged by nuisance algae at the beginning of the growing season. Rapid, early formation of algal mats at the time of flooding can prevent the establishment of newly emerged rice seedlings. Given that rapid growth of algae can be stimulated by the presence of nutrients (phosphorus and nitrogen) in the water, adaptation of fertilizer management practices (i.e. time of application, amount and type of fertilizer) may reduce the negative effects of the algae on the early establishment of rice. The main question is how rice algae assemblage would change in response to the amount and type of fertilizers. Field experiments were conducted during the summer of 2018 and the growth responses of the algae were evaluated under the various amount of nitrogen (urea) and phosphorus (triple superphosphate). PVC pipes (80 cm diameter), inserted into the soil, were utilized as the experimental units. Both Nitrogen (0, 50, and 150 kg ha-1) and phosphorous (0, 35, and 70 kg ha-1) were minimally incorporated into the soil prior to the flooding. The algae formation and coverage were observed and scored every second day for a month i.e. when the rice started to emerge through the water. Changes in the algae coverage were rapid during the season. The maximum algae coverage (i.e. bloom) was observed at 6 days after flooding but then started to decline slowly. Once the rice seedlings emerged from the water, algae coverage was almost disappeared. Although the presence of each fertilizer alone (N or P) found to stimulate the growth of algae (10% algal coverage), algae covered most of the experimental plots when the two fertilizers were applied together (up to 60% algal coverage). The initial results suggest that manipulation of the amount of fertilizers can mitigate the growth of algae, however, further studies are needed for a better understating of the algae growth dynamics and its impact on rice seedling establishment.

WILD RADISH (*RAPHANUS RAPHANISTRUM* L.) SEEDLING EMERGENCE IN NC. T. A. Reinhardt Piskackova*, K. M. Jennings, R. Richardson, C. Reberg-Horton, R. Leon; North Carolina State University, Raleigh, NC (144)

ABSTRACT

Predictive models for weed emergence are important to tools to take advantage of information technologies to increase efficacy and efficiency of Integrated Weed Management. While many studies have described ideal germination requirements, and vulnerable stages for management of wild radish, no empirical model has been developed. The emergence of wild radish was studied in agricultural fields in Clayton, NC from September to June. Chronological, Thermal, and Hydrothermal time were used to describe seedling emergence dynamics. All models needed a hybrid model to accommodate biphasic emergence patterns which reflect wild radish biological and adaptive strategies that could alter management decisions.

NON-CHEMICAL MANAGEMENT PRACTICES AND THEIR IMPACT ON WEED POPULATION DYNAMICS IN ORGANIC GRAIN PRODUCTION. S. L. Samuelson*, N. Rajan, R. Schnell, M. V. Bagavathiannan; Texas A&M University, College Station, TX (145)

ABSTRACT

There has been an increased global interest in organic food production. In an effort to lessen our dependence on herbicides, the adoption of cover crops as a means of weed management has been encouraged. A field study was established in September 2016 at the Texas A&M University research farm near College Station, TX on a site that was fallowed for 10 years. The experimental design was a randomized strip-split plot with three replications. The main plot treatments consisted of soybean-corn- sorghum rotation, with each crop planted in the first year, followed by the other two crops in sequence. The sub-plot treatments include: 1) Standard practice, which uses primary and secondary tillage operations for pre-plant weed control, incorporation of manure, and seedbed preparation; 2) summer cover crop and no-till planting; 3) summer

cover crop followed by a fall cover mulch and no-till planting; and 4) summer cover crop with the same fall cover mulch, but conventional tillage for seedbed preparation. Soil seedbank samples were collected after crop harvest each fall to determine the changes in weed seedbank size over time with different management practices. At 21 days after planting (DAP), weed seedling emergence and density were recorded by randomly placing four 1 m2 quadrats in each plot. Similar observations were carried out in fall in sub-plots planted with cowpeas at 21 DAP. Conventional tillage provided considerable weed control in the spring after planting of the cash crop. Fallowing the field for 10 years built weed pressure, especially johnsongrass, which posed a challenge for non-chemical weed control. However, this experiment presented a worst-case scenario for transitioning into organic systems with high background weed densities. Results provide valuable information for non-chemical weed control in organic grain production.

EXTENDING THE HOST RANGE OF A COMMERCIAL BIOHERBICIDAL FUNGUS. C. D. Boyette*[1], R. E. Hoagland[2], K. C. Stetina[1]; [1]USDA-ARS, Stoneville, MS, [2]USDA-ARS-CPSRU, Stoneville, MS (146)

ABSTRACT

PESTA GRANULAR MYCOHERBICIDE FOR COMBATING BROOMRAPE IN *VICIA FABA* FIELD IN EGYPT. Y. M. Shabana*[1], M. M. El-Hawary[2], M. E. Sadek[3]; [1]Mansoura University, El-Mansoura, Egypt, [2]Agricultural Research Center, Giza, Egypt, [3]Mansoura University, Mansoura, Egypt (147)

ABSTRACT

Crenate broomrape (*Orobanche crenata*) is an aggressive and injurious holoparasitic weed that has a strong impact on legumes cultivation in the Middle East, East Africa, and the Mediterranean region. A Substantial yield reduction, mainly due to crenate broomrape infestation, is imposed on faba bean with yields dropping from an average of 2.7 tons per hectare in 1998 to 0.6 tons per hectare in 2003, and a decrease of cultivated land from 17,650 hectares in 1991 to 800 hectares in 2000. Although a considerable number of herbicides have been tested as means for controlling broomrape, none of them had an effective control measure. In addition, high cost and toxicity of chemical herbicides also limit their application. Indigenous, weed-specific fungal pathogens can be used as safe and effective bioherbicides. As an alternative or adjunct to conventional weed control technology of chemical and mechanical controls, the bioherbicides offer excellent means of ecologically sound weed management. A production line for mass-producing high-quality granules of a biocontrol fungal strain using pasta-like process technology, at half industrial level was built up at Mansoura University, Egypt (Shabana *et al.* 2018). The granular mycoherbicides of *Fusarium semetictum* and *F. oxysporum* isolates were evaluated against *O. crenata* under open field conditions. The number of emerged *Orobanche* shoots, *Orobanche* shoots height, and *Orobanche* shoots dry weight were significantly decreased with increasing the mycohrbicide dose of the two Fusaria isolates as compared with the control treatment. There was a positive response of growth parameters (shoot height, dry matter content and leaf area index) of host plants (faba bean) to treatments with the Pesta-pelletized mycoherbicides in comparison with the control treatment. This positive effect of Pesta on growth parameters of the faba bean significantly increased with increasing the Pesta doses.

DEVELOPING HOST-SPECIFIC BIOHERBICIDE FOR MANAGEMENT OF W*ATERHYACINTH* IN EGYPT. Y. M. Shabana*; Mansoura University, El-Mansoura, Egypt (148)

ABSTRACT

Waterhyacinth (WH), the world's worst aquatic weed, causes annual losses to hydro-electricity generation, irrigation schemes, fisheries, riparian communities and water transport in excess of US$100 million. Thick mats of WH which can cover water bodies, reduce light and dissolved oxygen, drastically affecting water chemistry and aquatic plants and fauna and greatly increase water evaporation. In Egypt, the total amount of water loss by evapotranspiration due to WH infestation was estimated to equal 3.5 billion m^3 of water per year. This issue is projected to become more significant due to increasing Egyptian demand for irrigation water for the ever-increasing new reclaimed areas for agriculture in Egypt. WH is also a major threat to the ecosystem: it hampers biodiversity, affects fish and aquatic fauna, plant community structure and function, human health, and water supplies. It has also major impacts on economic activities and community livelihoods. Use of chemical herbicides in water is banned in Egypt due to environmental and health concerns. This leaves manual and machine removal (costing >US$7 million/yr) the only WH control option, yet the problem persists. Biocontrol using a native host-specific pathogen is an option. Shabana et al have shown that the fungal pathogen *Alternaria eichhorniae* isolate #5 (Ae5) from Egypt is specific to WH and is capable of severely suppressing this weed. Ae5 formulated in cottonseed oil emulsion caused 100% control of waterhyacinth in outdoor field plots 7–13 weeks after application and the efficacy of the bioherbicide was further improved when integrated with 3,4-methylenedioxy trans-cinnamic acid (MDCA), a phenylpropanoid pathway inhibitor that weakens the plant's defense system.

ISOXAZOLOPYRIDINES – HERBICIDES WITH NOVEL PSII INHIBITION CHARACTERISTICS FOR WEED CONTROL. D. A. Carrera*[1], S. Rühm[1], R. Campe[2], J. Lerchl[2]; [1]BASF SE, Ludwigshafen, Germany, [2]BASF SE, Limburgerhof, Germany (149)

ABSTRACT

The evolutionary arms race between resistant weeds and herbicides requires the never-ending introduction of novel mode of actions, which can replace the older ones, to maintain an effective and diverse management of weeds. Isoxazolopyridines are a class of compounds with a previously unknown mode of action, they show an outstanding post-emergence broadleaf weed control and selectivity toward monocot crops. They are a possible inhibitor of the photosynthetic electron transport chain, but the exact target and mode of action in the photosynthetic machinery remains to be elucidated. The most frequent target in the PSII complex is the D1 (psbA) protein in the reaction center, which is highly conserved in plants and photosynthetic algae and some D1 mutant *Chenopodium albiens* plants show an increased tolerance towards Isoxazolopyridines. However, different scout experiments were carried out and as a result, light harvesting proteins (LHCB) emerged as potential new targets. Chlorophyll *a* fluorescence is a powerful tool to monitor in vivo the photosynthetic efficiency, especially in photosystem II (PSII), because the variable fluorescence originates almost exclusively from PSII. Data from treated plants shows a slower and slightly distinct fluorescent profile of Isoxazolopyridines compared to other known D1 inhibitors, like atrazine, which could be attributed to the inhibition of the LHCB proteins.

CHARACTERIZATION OF *PHALARIS BRACHYSTACHYS* L. RESISTANT TO ALS INHIBITOR HERBICIDES IN WINTER WHEAT FROM IRAN. S. Golmohammadzadeh[1], J. Gherekhloo[1], C. Palma-Bautista[2], A. M. Rojano-Delgado[3], R. De Prado Amian*[4]; [1]Gorgan University, Iran, Iran, [2]University of Cordoba, CÓRDOBA, Spain, [3]University of Cordoba, Cordoba, Spain, [4]University of Cordoba, Córdoba, Spain (150)

ABSTRACT

Acetyl co-enzyme A carboxylase inhibitors are commonly used for post emergence control of grass weeds in broad leaf crops. Some of these herbicides are applied to control grass weeds in wheat and barley fields. Repeated application of the herbicide(s) characterized by having the same mode of action leads to increased selection pressure, which in turn contributes to the evolution of herbicide-resistant weeds. In this work, the ACCase (APP, CHD, and PPZ) inhibiting herbicides were studied in different biotypes of *Phalaris brachystachys*, by carrying out two different methods, a seed bioassay and whole-plant assay. Seventy-six biotypes of *P.brachystachys* were collected from wheat fields in different areas of Golestan province in Iran during the springs of 2015, 2016 and 2017, where ACCase inhibitors had been continuously applied for various periods. Log logistic dose-response curves were used to estimate the EC_{50} and GR_{50}. Seed bioassay results showed that the biotypes are resistant to applied herbicides with different resistance levels. By using the estimated parameters of concentration-response curves, a discriminating concentration was determined for diclofop-mthyl and clodinafop propargyl. Several dose response assays were carried out to determine and compare the biotype sensitivity of *P.brachystachys* to diclofop, clodinafop (APP), pinoxaden (PPZ) and cycloxydim (CHD). A dose response analysis showed a reduction in fresh weight as the dose increased; however, there were differences depending on the biotype and the herbicide. The biotypes showed resistance to the APP herbicides, with a resistance order of clodinafop- propargyl > diclofop-methyl. The majority of clodinafop-resistant biotypes were also resistant to diclofop. Some biotypes also showed cross-resistance to pinoxaden and cycloxydim. Some biotypes were clearly resistant to APP, CHD, and PPZ herbicides. On the basis of resistance index values (shoot dry weight R/ shoot dry weight S), dose-response assays revealed cross-resistance to the three herbicide families in the biotype from Iran, but varied in the resistance levels to other ACCase inhibiting herbicides tested. It is evident that *P. brachystachys* biotypes from the Iranian wheat fields have evolved resistance to a number of ACCase-inhibiting herbicides but still not knowing the involved resistance mechanisms. Additional resistance management practices may be necessary to prevent ACCase-inhibiting herbicides from becoming ineffective over wide areas.

ALLELOPATHIC RICE VARIETIES FOR WEED SUPPRESSION: A TOOL IN ORGANIC RICE. S. Abugho*[1], J. L. Samford[2], A. McClung[3], X. Zhou[4], M. V. Bagavathiannan[1]; [1]Texas A&M University, College Station, TX, [2]Texas A&M University, Eagle Lake, TX, [3]USDA-ARS, Stuttgart, AR, [4]Texas A&M University, Beaumont, TX (151)

ABSTRACT

Organic rice production requires effective weed management tools to tackle problematic weeds. Allelopathic rice varieties may play an important role in this regard, but the impact of potential allelopathic varieties on weed suppression is not well established under field conditions. Field experiments were conducted in the 2017 and 2018 rice growing seasons at the David Wintermann Rice Research Station, Eagle Lake, TX to determine the weed suppressive potential of four rice varieties (Jasmine 85, Rondo, PI 312777 and PI 338046), in comparison with Cocodrie (local inbred variety) and XL 753 (hybrid variety). Each variety was planted twice in each replication, with one plot receiving weed control applications kept weed free and the other receiving no weed control applications. The experiment was conducted using a randomized complete block design with four replications. Hemp sesbania (*Sesbania herbacea*), barnyardgrass (*Echinochloa crus-galli*), large crabgrass (*Digitaria sanguinalis*) and broadleaf signalgrass (*Urochloa platyphylla*) were the major weeds present in the study site. Total weed cover, weed biomass and rice grain yield were documented at harvest. Weed cover (100%=complete ground cover, 0%=weed-free) was visually estimated at 35, 45, 60, 75, and 90 days after planting (DAP). Relative grain yield was calculated based on the respective yield from the adjacent weed-free plots in each rice variety. Across the two years, the least weed infestation was recorded from PI312777 (42 to 55% weed coverage) and PI338046 (32 to 66%) at 45 DAP. In contrast, XL 753 had the most weed density (76 to 100%) at 45 DAP. Further, PI 312777 had the greatest yield relative to the weed-free plots with 42% and 56% in 2017 and 2018, respectively. The results illustrate the value of the allelopathic varieties (specifically PI312777 and PI338046) as a useful tool in the integrated weed management toolbox in organic rice production systems.

THE EVALUATION OF ORGANIC CLEANER FOR DICAMBA. G. LaBiche*[1], L. M. Lazaro[1], M. R. Foster[1], Z. Liu[2]; [1]Louisiana State University AgCenter, Baton Rouge, LA, [2]Louisiana State University, Baton Rouge, LA (152)

ABSTRACT

Soybean plants (*Glycine max* L. Merr.) can be sensitive to herbicides like 2,4-D and dicamba. Dicamba (2-methoxy-3,6-dichlorobenzoic acid) is a widely used herbicide in soybean production today. The most common issue with dicamba-based products is tank contamination, where herbicide residue is difficult to fully clean out of equipment. Conventional cleaning methods often are not reliable with dicamba-based products, can use large amounts of water, and can be time-consuming. A new organic tank cleaner to combat tank residue has been developed at Louisiana State University. There is no research on what effects this organic tank cleaner may have on 2,4-D or dicamba-based products and whether it can clean the boom or tank contamination effectively. Thus, the objective of this study was to compare the new organic tank cleaner against a standardized commercial tank cleaner (Protank®). A preliminary field trial was conducted at the Central Research Station in Baton Rouge, LA in 2018. Two dicamba-containing products (Xtendimax® and Engenia®), two tank cleaners (standard and organic), and two cleanout methods (an immediate rinse out and overnight soak of the boom), with a non-treated control were placed in randomized complete block design with six replications. The residue from all treatments were collected and sprayed onto dicamba-sensitive soybean. Soybean injury was assessed 14 and 21 days after treatment. The results are as follows: the control plots and the plots sprayed with organic and standard tank cleaner alone showed no injury, indicating none of the cleaners is phytotoxic. However, the standard tank cleaner, regardless of herbicide or the amount of time left in the boom, resulted in higher soybean injury than the organic cleaner. The amount of time that the cleaner was left in the boom did have a significant effect on tank contamination, with the 24-hour soak resulting in less injury overall. In addition, the plots sprayed with Xtendimax® residue had increased injury than plots sprayed with Engenia® residue. Furthermore, there was a significant difference in yield for Xtendimax® between the standard cleaner and the organic cleaner or the control plots. From this experiment it can be concluded that the new cleaner may be more effective and more efficient than the standard cleaner when used on Xtendimax® or Engenia®. Further field testing and additional herbicides need to be tested using the organic cleaner and additional industry standard tank cleaners.

INVESTIGATING DICAMBA UPTAKE AND TRANSLOCATION IN DICAMBA-TOLERANT TOMATO USING HPLC. R. Zangoueinejad[1], M. Alebrahim[2], T. Tseng*[3]; [1]Mississippi State University, mississippi st, MS, [2]University of Mohaghegh Ardabili, Ardabil, Iran, [3]Mississippi State University, Mississippi State, MS (153)

ABSTRACT

Absorption and translocation of dicamba was investigated at the drift rate (2.8 g ai ha^{-1}) on two commercial tomato cultivars (Money Maker and Better Boy, as control plants), and three tolerant wild accessions (TOM199, TOM198, and TOM300). Dicamba was quantified in three different part of the plant; T, top two leaves; M, middle two leaves; and R, root, at 1, 3, and 7 days after treatment (DAT) of dicamba. At 1 DAT, Money Maker absorbed the most dicamba (0.001 mg g^{-1}); at 3 DAT, all three accessions and Money Maker presented a lower dicamba absorption than Better Boy (0.00093 mg g^{-1}); and, at 7 DAT, Better Boy continued to absorb the most amount of dicamba (0.00041 mg g^{-1}). With regards to dicamba translocation, most of the dicamba was translocated to the top and middle sections of the plant, in all tomato

accessions and cultivars. TOM198 showed the highest translocation of dicamba to part T; 86, 86, and 74% at 1, 3, and 7 DAT, respectively. On the other hand, the highest percentage translocation in part M, was observed in Money Maker, at all time points. The overall pattern of dicamba movement was the same between cultivars and accessions, however, the amount of dicamba translocated by cultivars was more than the wild accessions. Tolerance to dicamba in wild accessions may thus be attributed to lower absorption of dicamba. Further studies will need to investigate the target site mechanism of dicamba tolerance in wild tomato accessions used in this study.

A NON-DESTRUCTIVE LEAF DISC ASSAY FOR RAPID DIAGNOSIS OF HERBICIDE RESISTANCE IN WEEDS. C. Wu*[1], A. Perez-Jones[2], P. Feng[3]; [1]Bayer Crop Science, St Louis, MO, [2]Bayer Crop Science, Chesterfield, MO, [3]Bayer Crop Science, Saint Louis, MO (154)

ABSTRACT

Rapid diagnosis is very critical to monitoring weed resistance allowing actions proactively before dissemination. Traditionally, characterizat

IMPORTANCE OF THE IMAZAMOX EXUDATION IN THE RESISTANCE LEVEL OF A *EUPHORBIA HETEROPHYLLA* BIOTYPE. A. M. Rojano-Delgado[1], C. Palma-Bautista[2], D. A. Mora[1], J. Vazquez-Garcia[1], J. M. Rosario[3], J. Portugal[4], R. De Prado Amian*[5]; [1]University of Cordoba, Cordoba, Spain, [2]University of Cordoba, CÓRDOBA, Spain, [3]Universidad Católica Tecnológica del Cibao, La Vega, Dominican Republic, [4]Polytechnic Institute of Beja, Beja, Portugal, [5]University of Cordoba, Córdoba, Spain (155)

ABSTRACT

Euphorbia heterophylla is a weed species that is extended in large areas in Brazil. The imazamox controlled this species for a long time, but its abusive use caused resistant biotypes. In this work, the root exudation as a resistance mechanism was studied in resistant (R) and susceptible (S) biotypes of *E. heterophylla* from Brazil. The biotype R has only an ALS resistance mechanism previously studied, as it is a S-653-N mutation found in the ALS gene. Therefore, neither imazamox absorption nor imazamox metabolism was involved in the resistance. But the mutation as a unique resistance mechanism does not explain the high resistance found in the R biotype (GR_{50} for imazamox in R biotype is 1250.2 versus 7.43 g ai ha^{-1} for S biotype). A mix with ^{14}C-imazamox and formulated imazamox, with a concentration of 40 g ai ha^{-1} and 1.65 kBq mL^{-1} (100 000 dpm) was applied on the adaxial surface of the plants grown in a hydroponic system. The time intervals studied were 3, 6, 12, 24, 48 and 96 hours after treatment (HAT). Interestingly, of the total ^{14}C absorbed (as imazamox), large amounts were found in the nutritive solution of both R and S plants. For S plants 1.9 to 37.6 % of imazamox was found in the solution from 3 to 96 HAT, respectively, and for R plants 1.6 to 64.8 % was found in the same time interval. The root exudation also seemed to be a mechanism regulating the biotype resistance, since it was able to exude a large amount of herbicide (~70 %).

MULTIPLE RESISTANCE TO HERBICIDES IN A *PARTHENIUM HYSTEROPHORUS* BIOTYPE FOUND IN CARIBBEAN ZONE. D. A. Mora[1], J. M. Rosario[2], C. Palma-Bautista[3], R. Domínguez-Mendez[1], A. M. Rojano-Delgado[1], J. Portugal[4], R. De Prado Amian*[5]; [1]University of Cordoba, Cordoba, Spain, [2]Universidad Católica Tecnológica del Cibao, La Vega, Dominican Republic, [3]University of Cordoba, CÓRDOBA, Spain, [4]Polytechnic Institute of Beja, Beja, Portugal, [5]University of Cordoba, Córdoba, Spain (156)

ABSTRACT

Currently more than 21000 ha are in production in the Dominican Republic; mostly exporting bananas, which make their cultivation one of the main axis of the economy in productive areas, especially in the provinces of Montecristi and Azua. According to the information from technicians and farm managers, some *Partenium hysterophorus* populations have developed resistance to products used such as PSI and PSII, EPSPS, GS, ALS, PPO inhibitor herbicides and auxine synthetics. The fast screening (percentage survival plants) on *P. hysterophorus* resistant (R) and susceptible (S) plants showed that S populations died at field doses of all herbicides, except for paraquat (100 %). However, R plants at field doses showed different survival levels: glyphosate and paraquat > atrazine and flazasulfuron > glufosinate > fomesafen > 2, 4-D. The greenhouse tests showed high resistance (FR: GR_{50} R / GR_{50} S) to glyphosate, flazasulfuron and fomesafen and medium resistance to atrazine, glufosinate and 2,4-D and a natural tolerance to paraquat (FR: 1.0). In vitro studies of the EPSPS, PS II, ALS, GS and PPO activities showed significant differences between the I_{50} values (dose of herbicide needed to reduce the activity to 50%) of the R and S populations treated with glyphosate, atrazine, glufosinate and flazasulfuron, but not in the case of the PPO activity that seems to be very sensitive to fomesafen. The studies carried out on the absorption and translocation of ^{14}C-2,4-D, allow us to conclude that the lower translocation of this herbicide in the R population compared with the S could be one of the causes of the resistance to 2,4-D herbicide, while the low absorption of ^{14}C-paraquat shown in both populations would explain the natural tolerance of *P. hysterophorus*. This is the first case of multiple resistance to herbicides with different action mechanisms confirmed in *P. hysterophorus*.

RESISTANCE TO ALS INHIBITORS DUE TO TRP574LEU SUBSTITUTION IN REDROOT PIGWEED AND TALL WATERHEMP FROM MISSISSIPPI. V. K. Nandula*[1], D. Giacomini[2], J. Ray[3]; [1]USDA-ARS, Cleveland, MS, [2]University of Illinois, Urbana, IL, [3]USDA, Stoneville, MS (157)

ABSTRACT

V. K. Nandula[1], D. A. Giacomini[2], and J. D. Ray[1]

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Several *Amaranthus* spp. around the world have developed resistance (and cross-resistance) to various herbicide modes of action. Populations of *A. tuberculatus* and *A. retroflexus* in Mississippi have been suspected to be resistant to one or more acetolactate synthase (ALS)-inhibiting herbicides. Whole plant dose-response experiments with multiple ALS inhibitors, ALS enzyme assays with pyrithiobac, and molecular sequence analysis of ALS gene constructs were conducted to confirm and characterize

the resistance profile and mechanism of resistance in the *A. tuberculatus* and *A. retroflexus* populations. Both *A. tuberculatus* and *A. retroflexus* populations were found to be resistant to imazethapyr (imidazolinone), pyrithiobac (pyrimidinyl thiobenzoate), and trifloxysulfuron (sulfonylurea) herbicides, surviving rates of 8X to 16X the labeled rates. Their respective susceptible counterparts were controlled by 1X rates or less. ALS assays indicated a target-site-based resistance mechanism in both species. DNA sequencing revealed the presence of a known resistance-conferring point mutation, Trp574Leu in both *A. tuberculatus* and *A. retroflexus*. ALS resistance in *Amaranthus* spp. severely limits postemergence management options for growers in Mississippi.

RESISTANCE TO PROTOPORPHYRINOGEN OXIDASE (PPO) INHIBITORS IN PALMER AMARANTH FROM MISSISSIPPI. V. K. Nandula*[1], W. Molin[2]; [1]USDA-ARS, Cleveland, MS, [2]USDA-ARS, Stoneville, MS (158)

ABSTRACT

V. K. Nandula[1], D. A. Giacomini[2], and W. T. Molin[1]

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Widespread adoption of glyphosate-resistant (GR) crops and the associated use of glyphosate has resulted in evolution of GR weeds in several states including Mississippi. Currently, Mississippi leads the nation with 9 GR weed species. Among these are several pigweed (*Amaranthus*) species including Palmer amaranth (*A. palmeri*), tall waterhemp (*A. tuberculatus*), and spiny amaranth (*A. spinosus*). GR Palmer amaranth populations, in particular, are widespread across the state with some exhibiting multiple resistance to acetolactate synthase (ALS)-inhibiting herbicides such as pyrithiobac. Protoporphyrinogen oxidase (PPO)-inhibiting herbicides are one of the few chemical options left for managing GR weeds but we found that several individual plants of Palmer amaranth population were able to surviv two or more targeted treatments of fomesafen, a PPO inhibitor, at a 1X rate. Forty-three surviving plants were sampled for leaf tissue and analyzed for the presence of a deletion mutation, ΔG210, originally documented in PPO inhibitor-resistant waterhemp. Only one of the forty-six plants revealed the presence of the above mutation. Further dose response studies with fomesafen and cross resistance studies with selected PPO inhibitors indicated postemergence resistance to acifluorfen, fomesafen, lactofen, carfentrazone, and sulfentrazone. Reduced response with saflufenacil is under investigation. Preemergence application of fomesafen, flumioxazin, and oxyfluorfen did not indicate any presence of resistance.

HERBICIDE RESISTANCE SCREENING STUDIES ON A *PHALARIS MINOR* POPULATION FROM INDIA. V. K. Nandula*[1], S. Singh[2]; [1]USDA-ARS, Cleveland, MS, [2]CCSHAU, Hisar, India (159)

ABSTRACT

V. K. Nandula[1] and S. Singh[2]

[1]USDA-ARS, Stoneville, MS

[2]CCSHAU, Hisar, India

Phalaris minor is a troublesome grass weed in small grain growing areas in northwestern India. Several populations of *P. minor* have developed multiple resistance to PS II inhibitors such as isoproturon, ALS inhibitors such as sulfosulfuron, and ACCase inhibitors such as clodinafop. A resistant population from India was screened with several herbicides across many modes of action, both in the presence and absence of inhibitors of cytochrome P450 and glutathione-S-transferase inhibitors. Only glyphosate and atrazine provided complete control of the resistant *P. minor* population. Studies are underway for further characterization of the resistance profile in this population with a future objective of determination of target site based and metabolic resistance mechanisms.

AN INTERACTIVE DATABASE FOR EXPLORING THE PHYSICOCHEMICAL PROPERTIES OF HERBICIDES AND HERBICIDE LEADS. J. S. Mylne*, M. N. Gandy, M. G. Corral, K. A. Stubbs; The University of Western Australia, Perth, Australia (160)

ABSTRACT

We calculated the experimental and estimated physicochemical properties of 334 commercial herbicides and used the data to make a dynamic, electronic database that adopts the Simplified Molecular-Input Line-Entry System (SMILES) for describing the structure of chemical molecules. The database is in Microsoft® Excel® format so to navigate the 334 herbicides is simple; it allows the visualisation of important chemical and biochemical data relevant to herbicides in a dynamic format. It is also possible to expand the content of the database with new compounds and even new parameters by using SMILES codes and the scripts, which are provided. As Clarke, Delaney, Tice and Lindell have observed before, the chemical properties that make a successful herbicide are generally similar to those chemical properties that make a successful oral human drug based on Lipinski's rules, which centre on molar mass, Log P and the number of hydrogen bond acceptors and donors. This database should prove useful to scientists engaged in herbicide discovery and development as it allows rapid comparison of new herbicidal compounds to the chemical properties of known herbicides.

HERBICIDE DISCOVERY AND DEVELOPMENT 2020, PERTH. J. S. Mylne*, K. A. Stubbs, J. Haywood; The University of Western Australia, Perth, Australia (161)

ABSTRACT

The Organising Committee warmly welcome you to attend the inaugural Herbicide Discovery and Development meeting (HDD2020) to be held in Perth

HDD2020 is being organised by Dr Joel Haywood and the research groups of Associate Professors Mylne (mylne.org) and Stubbs in the University c

The meeting will focus on presentations from students and early career researchers, supported by a small number of distinguished international

Our international keynote speakers so far include Prof. Stephen Duke (USDA), Prof. Yi Tang (UCLA), and Dr Ruth Campe (BASF, Germany). Australi

January is summer down under so this conference offers science, summer and surf. To find out more, go to http://hdd2020.org, e-mail secretaria

INSIGHTS INTO THE GENETIC BASIS OF GLUFOSINATE RESISTANCE IN ITALIAN RYEGRASS (*LOLIUM MULTIFLORUM*) FROM CALIFORNIA. S. Morran*[1], M. Matzrafi[1], P. Tehranchian[2], M. Jasieniuk[1]; [1]University of California, Davis, Davis, CA, [2]University of Arkansas, Davis, CA (162)

ABSTRACT

Italian ryegrass (*Lolium multiflorum*) is an annual grass found throughout the United States and a major weed of agricultural systems. Recently, a population of ryegrass collected from Lake County of California was found to be resistant to the non-selective herbicide glufosinate. Resistance to glufosinate has been attributed to altered uptake of the herbicide, reduced translocation and/or a change in the sensitivity of the glutamine synthase (GS) enzyme, preventing inhibition and the resultant accumulation of ammonia in the cell. A non-synonymous mutation, Asp171Asn, in the GS2 gene has been associated with glufosinate resistance in *Lolium*. Sequencing of the GS2 gene in resistant plants from this population revealed both heterozygous and homozygous individuals with the target site mutation (TSM). The TSM was not, however, present in all resistant plants. Resistance in this population may be partially associated with this mutation though other mechanisms either monogenic or multigenic may also be conferring resistance. As part of our work toward understanding this population, including heritability and potential spread of resistance, we are investigating the inheritance patterns of this resistance trait.

SOYBEAN RESPONSE TO DICAMBA IN PLOT-SCALE FURROW IRRIGATION WATER. C. D. Willett*, E. M. Grantz, J. Lee, E. L. Archer, R. T. Grewe, J. K. Norsworthy; University of Arkansas, Fayetteville, AR (163)

ABSTRACT

In groundwater depletion zones, producers have implemented tailwater recovery systems to collect and recycle irrigation and runoff. These systems conserve groundwater, but could circulate herbicides between fields from resistant to non-resistant crops. This study investigated the potential for non-resistant soybean to suffer injury and yield loss when exposed to dicamba in furrow irrigation water. Irrigation treatments were applied to 25-ft furrow sections at a constant volume across a range of dicamba concentrations, equivalent to 7.6, 16, 63, 160, and 630 g ha^{-1}. Five 25-ft sections within 2 control furrows were irrigated with unamended water, and sections within 4 furrows were irrigated at each concentration. Plant injury (0-100%) was assessed visually relative to controls 14 days after treatment for populations within the mid 15 ft and bottom 5 ft of each section, representing average and maximum exposure to dicamba, respectively. Height of select plants were measured at R8, and seed was hand harvested from 5 ft in each of 2 treated rows for both exposure populations after senescence. Kruskal-Wallis tests indicated three groups of application rates resulting in no (7.6-16 g ha^{-1}), low (63-160 g ha^{-1}), or high (160-630 g ha^{-1}) damage based on plant injury and height reduction in both exposure populations. Yield reductions were similarly grouped for the average exposure population, but were divided between a no effects (7.6-63 g ha^{-1}) and an effects (up to 100% yield reduction; 160-630 g ha^{-1}) group for the maximum exposure population. Effective doses to 50% of the population ranged from 34-50 g ha^{-1}, depending on critical damage level and exposure. Findings suggest soybean is less sensitive when exposed to dicamba in furrow irrigation water than in drift. However, irrigation may deliver larger herbicide doses due to the large volume of water applied. Irrigation in this study was just 20-25% of a typical 3 ac-in event.

DYNAMICS OF *FUSARIUM VERTICILLIOIDES* AFTER HERBICIDE TREATMENT ON MAIZE STUBBLE. W. N. Braz, R. A. Guimarães, J. P. Silva, F. V. Medeiros, F. C. Medeiros*; Federal University of Lavras, Lavras, Brazil (164)

ABSTRACT

Fusarium verticillioides is the most important pathogen associated to ear rot and fumonisin kernels contamination of maize cultivated in the tropics. It overwinters in the maize stubble and the disease epidemics depends on various factors, among which its inoculum level. Various factors govern the dynamics of stubble-borne pathogens among which herbicide spray. We evaluated the role of herbicides commonly used in corn on the dynamics of *F. verticillioides*. Four of the most largely used herbicides for weed management on corn (tembotrine, nicosulfuron, atrazine and glyphosate) were tested on the mycelial growth and sporulation of the pathogen in vitro, sporulation of the pathogen in autoclaved stalks and quantification of the pathogen (qPCR) in stalks naturally infected with *F. verticillioides* under field conditions. Each herbicide was amended to potato-dextrose agar medium at different concentrations (0, 25, 50 and 100% of the field recommended dose of each product) and the fungus was evaluated for the mycelial growth and sporulation. Each product was further evaluated for the sporulation rate in stalks obtained from plants alive (at V5) and dead (stubble) autoclaved and infested with the pathogen. Finally, the DNA concentration (qPCR) of *F. verticillioides* in stalks naturally infected under field conditions, was evaluated. For this purpose, the stalks were sprayed with each product upon post-emergence herbicide spray timing and were processed for qPCR quantification of *F. verticillioides* before and 15 days after spraying. There was a significant effect of the herbicides on the pathogen development and this effect was different according to the considered product. Glyphosate promoted an increase in the DNA concentration of the pathogen in stalks under field conditions but it did not interfere on the mycelial growth or sporulation of the pathogen under controlled conditions. Tembotrione reduced the mycelial growth and increased sporulation of the pathogen in the lab and the fungal DNA concentration under field conditions. Atrazine promoted the highest effect on the reduction of the mycelial growth and the second highest sporulation of the pathogen in the lab, while this effect was not observed in the field trial. On the other hand, nicosulfuron had an effect similar to atrazine in the lab but had the highest impact on the increase in *F. verticillioides* DNA concentration under field conditions. Therefore, nicosulfuron is the herbicide with highest effect on *F. verticillioides* development followed by tembotrione and glyphosate.

RICE PREEMERGENCE HERBICIDES WASHOFF FROM RYEGRASS STRAW UNDER SIMULATED RAINFALL. M. Tomazetti, E. R. Camargo*, J. Gomes, L. Vieira, J. Refatti, V. Gehrke; Federal University of Pelotas, Pelotas, Brazil (165)

ABSTRACT

Rice establishment under no-till system has been developed using ryegrass (*Lolium multiflorum*) as the main cover crop. Cover crops can affect the herbicide dynamics, either by herbicide straw retention or by modification in soil conditions such as soil moisture and temperature. Herbicides can reach the soil after rain events, however, this process depends of herbicide molecule and period between application and first rainfall. To date, research in this subject was not performed considering the specificity of rice in lowland areas. Therefore, this research was conducted to study the interaction among herbicides (clomazone, imazapyr+imazapic, pendimethalin and quinclorac) and different simulated rainfall periods (2, 7 and 14 days after herbicide application - DAA) on herbicide washoff. The dose used was according to the recommendation for rice in Brazil. The herbicides were applied on ryegrass straw placesd over a metal structure that allowed water collection after rainfall simulations. Rainfall was simulated using an equipment developed for this purpose delivering 20mm in each designed period. Water was collected and analyzed by liquid chromatography. Herbicide interception by straw at the application moment was 98% of spray solution (quantified by the Brilliant Blue FD&C mixture to spray solution and analyzed by spectrophotometry at 630nm wavelength). The research was performed under completely randomized design with four replications. Herbicide washoff in straw, considering the first simulated rainfall was in follow order: pendimethalin (20,9%) = clomazone (42,9%) < imazapyr (98,5%) = imazapic (99,4%) = quinclorac (99,5%). These results showed that, after first rainfall event, almost 100% of imidazolinones and quinclorac were removed from the straw, and clomazone and pendimethalin may have been sorbed or dissipated. According to physicochemical properties of the molecules, the possible fate of clomazone may have been the volatilization, while for pendimethalin, the sorption on straw was probably the predominant process; imazapyr, imazapic and quinclorac were more washed probably due to their high water solubility, that allows less sorption in organic carbon surfaces such as the ryegrass straw. At 7 DAA, 72,3 and 65,4% of imazapyr and imazapic, respectively, were washed off; clomazone was removed by 19,9%, pendimethalin by 10,4%, and quinclorac by 83,5% with the rain. In the last simulated rainfall (14 DAA), the washoff percentage statistically decreased for almost all herbicides in relation to first rain (clomazone 11,4%, imazapyr 61,4%, imazapic 53,7%, and quinclorac 94%), except for pendimethalin (6,7%), that the concentration was already low at 2 DAA. Despite the fact that quinclorac concentration has decreased over time (2 to 14 DAA), the quantity in last rain was still high, showing that this molecule can be very recalcitrant when deposit over ryegrass straw. Therefore, the conclusion is that clomazone and pendimethalin demonstrated the lowest percentage of removal from ryegrass straw followed by imidazolinones and by quinclorac. The later was capable to persist and be washed over 90% after 14 days without rainfall.

RELATIVE TOXICITY OF SELECTED ORGANIC AND CONVENTIONAL HERBICIDES TO WORMS. E. G. Mosqueda, A. T. Adjesiwor*, A. Kniss; University of Wyoming, Laramie, WY (166)

ABSTRACT

Agrochemicals have been an important component of agricultural production systems. However, there are increasing concerns on the effect of agrochemicals on soil biota and ecosystems. We evaluated the effects of commonly used herbicides and household chemicals on nightcrawlers (*Lumbricus terrestris* L.). The experiment was conducted on 19 Feb. 2018 (Exp. 1) and repeated on 27 Jun. 2018 (Exp. 2). In both experiments, there were 13 treatments comprising 10 herbicides: atrazine (Aatrex), nicosulfuron (Accent Q), dicamba (Clarity), s-metolachlor (Dual Magnum), paraquat (Gramoxone), pendimethalin (Prowl H_2O), glyphosate (Roundup PowerMax), and clethodim (SelectMax), caprylic acid plus capric acid (Suppress EC), pelargonic acid (Scythe); an adjuvant (nonionic surfactant, Preference), a combination of two household chemicals (vinegar and dish soap), and a non-treated control. All chemicals were applied at field use rates as recommended on the herbicide label, or, in the case of vinegar plus soap, at a concentration we found somewhere on the internet. Treatments were arranged in a completely randomized design with 10 replicates. Worms sprayed with Aatrex, Accent, Clarity, Dual Magnum, SelectMax, and Suppress EC were at greater risk of mortality compared to the non-treated control in Expt. 1. In Expt. 2, chemical treatments did not increase the risk of worm mortality. Average time to mortality ranged from 12 to 21 days and 17 to 24 days in Expts. 1 and 2, respectively. Both organic and conventional herbicides evaluated in this study present a low risk of acute toxicity to worms when applied at recommended rates.

EFFECT OF BENTAZON AND IODOSULFUROM-METHYL ON THE ANTIOXIDANT METABOLISM OF *LOTUS CORNICULATUS* L. N. S. Correa[1], F. Reolon*[1], C. L. Moraes[2], C. F. Larré[1], D. M. Moraes[1]; [1]Federal University of Pelota, Pelotas, Brazil, [2]Federal University of Pelota, Pelotas, British Indian Ocean (167)

ABSTRACT

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BURNING SUGARCANE RESIDUE: AN INTEGRATED APPORACH FOR MANAGING SURFACE DEPOSITED DIVINE NIGHTSHADE AND ITCHGRASS SEED. D. J. Spaunhorst*; USDA-ARS, Houma, LA (168)

ABSTRACT

In Louisiana, growers remove sugarcane residue following green-cane harvesting by prescribed burning. Divine nightshade [*Solanum nigrescens* (Mart. & Gal)] and itchgrass [*Rottboellia cochinchinensis* (Lour.) Clayton] are problematic weeds in Louisiana sugarcane production. The objective of this study was to determine the effects of dry heat and exposure duration on divine nightshade and itchgrass emergence. Divine nightshade and itchgrass seeds were exposed to three temperature levels (100, 150, and 200°C) for seven exposure timings (0, 5, 10, 20, 40, 80, and 160 s). Divine nightshade emergence was not completely inhibited at 200°C for 160 s. However, itchgrass exposed to 150°C for 40 s or longer failed to emerge. Exposure to 150°C for 5 to 20 s and 200°C for 5 to 10 s resulted in more than 100% divine nightshade emergence, presumably short periods of heat exposure alleviated seed dormancy. Results from this study showed itchgrass seed could be controlled with dry heat, but prescribed burns that produced temperatures below 100°C or temperatures greater than 150°C for short durations may not control all divine nightshade seeds. The aforementioned temperature and exposure time that allowed divine nightshade to survive, introduced the potential for divine nightshade to become more abundant. The fluid-filled fruit capsule that contained divine nightshade seed likely insulated the seed from being exposed to extreme temperatures.

CONTROL OF *AMARANTHUS PALMERI* RESISTANT TO ALS AND EPSP INHIBITORS WITH PRE AND POSTEMERGENCE HERBICIDES IN INTERCROPPING OF CORN AND MARANDU GRASS. F. S. Ikeda*[1], S. D. Cavalieri[1], F. M. Lima Júnior[2], L. H. Metz[2], B. T. Fonseca[2], F. Poltronieri[2]; [1]Embrapa, Sinop, Brazil, [2]Federal University of Mato Grosso, Sinop, Brazil (169)

ABSTRACT

The Palmer´s amaranth is in eradication process at Mato Grosso, due to its potential risk to national agriculture. The objective of this work was to study management alternatives of this species, with a randomized block design and factorial scheme (2 x 5) with four blocks, two systems ([single and intercropping maize with marandu grass (Urochloa brizantha cv. Marandu)]. and three herbicidal treatments (ae g ha-1): atrazine (2,500) PRE, atrazine (2,500) PRE / atrazine + tembotrione (1,500 + 50) POST and atrazine + tembotrione (1,500 + 50) POST. The herbicides were applied with CO2 pressurized sprayer and application volume of 200 L ha-1 . The control of Palmer's amaranth and marandu grass intoxication were evaluated at 7 and 21 days after application (DAA) with grades from 0 to 100. At 7 and 21 DAA, the applications in POST and PRE + POST showed similar control of the Palmer´s amaranth, without influence of the cultivation systems. At 7 and 21 DAA, there was effect of the system in the application only in PRE and non-weeded control, without differing among them, being the greater control in the intercropping (> 80% in the two evaluations). There was no significant difference ($p < 0.05$) for stand, number of rows / ear and yield (kg ha-1), although the height of insertion of the spike and maize and grain / row plants was higher in the intercropping. The application in PRE did not intoxicate the marandu grass, unlike those in POST (approximately 20% at 21 DAA), besides not reducing the density and the dry mass of the marandu grass. It is concluded that the management in the maize associated with marandu grass controls the Palmer's amaranth.

PALMER AMARANTH (*AMARANTHUS PALMERI*) CONTROL IN XTENDFLEX AND ENLIST COTTON (*GOSSYPIUM HIRSUTUM*). K. R. Russell*[1], P. A. Dotray[1], J. W. Keeling[2]; [1]Texas Tech University, Lubbock, TX, [2]Texas A&M AgriLife Research, Lubbock, TX (170)

ABSTRACT

Palmer amaranth (*Amaranthus palmeri* S. Wats) is a native summer annual weed to the cotton (*Gossypium hirsutum*) growing region of the Texas High Plains. Glyphosate-resistant Palmer amaranth was first found in Georgia in 2005 and has rapidly spread across the southern US. Glyphosate-resistant Palmer amaranth was found in the Texas High Plains in 2011. Over-reliance of glyphosate and underutilization of other herbicide modes of action has led to the development and spread across the area. Two group O herbicides (dicamba and 2,4-D) can now be used in-crop to control troublesome weeds such as Palmer amaranth due to the release of XtendFlex™ and Enlist™ cotton varieties. To prevent over reliance of group O herbicides, it will be important to implement multiple methods of weed control to manage Palmer amaranth populations. The objective of this research was to evaluate season-long weed control in XtendFlex™ and Enlist™ cotton using several different weed management systems that include the use of dicamba in XtendFlex™ cotton and 2,4-D choline in Enlist™ cotton. A field study was established in a randomized complete block design in Lubbock, Texas using a variety of herbicides at different application timings to manage Palmer amaranth. All treatments included bed listing followed by rod weeding to control early emerged weeds and to start clean at planting. Weed management treatments included one or more of the following: trifluralin at 1.12 kg ai/ha applied preplant; prometryn at 1.35 kg ai/ha applied preemergence; S-metolachlor at 1.36 kg ai/ha; dicamba at 0.56 kg ae/ha or 2,4-D choline at 1.06 kg ae/ha tank mixed with glyphosate at 1.13 kg ae/ha applied early and mid-postemergence; and interrow cultivation. In the XtendFlex™ cotton systems, differences in Palmer amaranth control ranged from 79% following the base treatment of two POST applications of dicamba and glyphosate to 100% when four additional weed management inputs were used during the growing season. Palmer amaranth was controlled >95% following three weed management inputs plus the base treatment of two POST applications of dicamba and glyphosate. In the Enlist™ system, Palmer amaranth control ranged from 69% in the base two POST applications of 2,4-D and glyphosate program to 98% following four additional weed management inputs.

ARTIFICIAL INTELLIGENCE BASED SEMI-AUTOMATIC HERBICIDE SPRAYER SYSTEM. V. Singh*, A. Sosa, A. Gutierre, A. Knowlton, M. A. Acosta, J. Lusher, S. Kalafatis, M. V. Bagavathiannan; Texas A&M University, College Station, TX (171)

ABSTRACT

In recent years, sensor technologies and artificial intelligence-based systems have paved ways in agriculture settings. Sensor suits and data management framework are gaining significant popularity as a potential technology that can assist in precision weed management. An artificial-intelligence based spraying system was developed for TxDoT (Texas Department of Transportation) truck for roadside herbicide applications. The system utilized computing device attached with two camera sensors. Hundreds of johnsongrass (*Sorghum halepense*) pictures (main roadside weed in Texas) were fed to the system for machine-learning algorithm framed in Python®. The sprayer system is capable of identifying johnsongrass and triggers spray application after detection. Apart from spray applications, the system tracks temperature, humidity, wind speed and location coordinates at the time of spraying. The system provides weather output file after completion of spray operation. This semi-automated sprayer system can decrease herbicide usage while managing roadside weeds. However, further refinements are required as system is slow and takes few seconds for processing and triggering herbicide. This issue could be resolved by integrating with higher computing device/laptop or to trigger herbicide based on green vegetation instead of specific weed.

EVALUATION OF REMOTELY PILOTED AERIAL APPLICATION SYSTEMS (RPAAS) FOR HERBICIDE APPLICATION. V. Singh*[1], M. Latheef[2], D. Martin[2], M. V. Bagavathiannan[1]; [1]Texas A&M University, College Station, TX, [2]USDA-ARS, College Station, TX (172)

ABSTRACT

The use of unmanned aerial application systems (UAAS) in production agriculture has gained traction over piloted aircrafts in the United States for site-specific management of crop pests in difficult terrains not easily accessible by manned aircraft. The UAAS have the potential to occupy this niche because of its ability to fly at low altitudes and to hover closer to plant canopy at various heights and ground speed with increased precision and safety. A field study was conducted in summer 2018 at College Station, TX to evaluate the efficacy of UAAS spray technologies for postemergence herbicide application in comparison to conventional backpack sprayer. A spray mix of water with fluorescent dyes were applied on Palmer amaranth (*Amaranthus palmeri*) and ivyleaf morningglory (*Ipomoea hederacea*) with a remotely piloted UAAS aircraft at 18.7 and 37.4 L ha^{-1} and a CO_2 pressurized backpack sprayer at 140 L ha^{-1}. Two types of artificial samplers, water-sensitive papers (WSP) and Mylar cards were deployed to determine droplet spectra and spray deposits, respectively. Droplet images on WSP samplers and fluorescent droplets on weed leaves were analyzed using a commercial imaging and Java-based ImageJ software, respectively. Mylar deposition was determined by fluorometry. This experiment was conducted as a completely randomized block design with four replications and was repeated two weeks later. Spray application treatments showed significant differences in droplet density at the top and bottom surfaces of the leaves. Higher volume treatment (140 L ha^{-1}; BP-15) received significantly more droplets on the top surface (adaxial) than lower spray rate UAS treatments. UAS-based spray applications indicated higher droplet density□30%) at abaxial surfaces which would be helpful in increasing the efficacy of contact herbicides.

UAV-BASED IMAGING FOR WEED IDENTIFICATION IN ROW CROPS. V. Singh*, B. B. Sapkota, M. Bishop, D. Cope, M. V. Bagavathiannan; Texas A&M University, College Station, TX (173)

ABSTRACT

The use of UAS brings game-changing capabilities to weed management in agriculture. UAS offer an opportunity to scout for weeds over the crop canopies with high precision and efficiency. Field studies were carried out during 2017 and 2018 at College Station, TX to identify various weed species in soybean fields using hyperspectral data and RGB images. Hyperspectral data at 700 - 1150 nm wavelength could easily distinguish Palmer amaranth (*Amaranthus palmeri*), and soybean. However, differences between waterhemp (*Amaranthus tuberculatus*) and johnsongrass (*Sorghum halepense*) were meagre in terms of reflectance. Wavelet analysis was carried out on hyperspectral data and coefficients were calculated using Continous Wavelet Transformation (CWT). The modulus maxima lines are extracted from the CWT coefficients at each scale highlight spectral features such as the green peak, red edge and near-infrared absorptions. These features have the potential to be used for diagnostic weed species classification. Object-segmentation based RGB image analysis (0.8 cm/pixel resolution) could distinguish soybean broadleaf weeds with high accuracy (95%). However, further frequency analysis (CWT) would be performed on RGB images of grass weeds owing to lower success rate of discrimination (60%).

DISTRIBUTION OF HERBICIDE RESISTANT WATERHEMP (*AMARANTHUS TUBERCULATUS*) ACROSS ROW CROP PRODUCTION SYSTEMS IN TEXAS. V. Singh*[1], R. Garetson[1], P. A. Dotray[2], S. A. Nolte[3], G. Morgan[1], M. V. Bagavathiannan[1], J. McGinty[4]; [1]Texas A&M University, College Station, TX, [2]Texas Tech University, Lubbock, TX, [3]Texas A&M AgriLife Extension, College Station, TX, [4], College Station, TX (174)

ABSTRACT

A survey was conducted in the major row-crop production regions of Texas to determine waterhemp response to glyphosate (EPSPS-inhibitor), atrazine (PSII-inhibitor), pyrithiobac (ALS-inhibitor), tembotrione (HPPD-inhibitor), fomesafen (PPO-inhibitor), and dicamba (Synthetic auxin). A total of 127 waterhemp populations were evaluated for the level of sensitivity to these herbicides. Based on the response observed, each population was categorized as resistant (<50% injury), less sensitive (50 to 89% injury), or susceptible (90 - 100% injury). For glyphosate, about 27% of all tested populations were resistant and 20% were less sensitive. The Gulf Coast region had the most glyphosate-resistant populations (46% of the populations from this region), followed by the Blacklands region (9%). A dose-response assay of a highly-resistant waterhemp population (TX-25) exhibited 8-fold resistance to glyphosate when compared to a susceptible standard. Waterhemp resistance to atrazine also was common in the Gulf Coast region. The population that showed the highest resistance to atrazine (TX-31) exhibited 47- and 68-fold resistance to this herbicide when applied POST and PRE, respectively. Widespread resistance to pyrithiobac has been observed in waterhemp populations throughout the Blacklands and Gulf Coast regions. The highly resistant population was 61-fold resistant compared to a susceptible standard. No high level resistance was detected for tembotrione, dicamba, or fomesafen. However, there was a high variability in the level of tolerance to tembotrione and dicamba, especially among the populations from the Gulf Coast region. One waterhemp population exhibited reduced sensitivity to fomesafen, but the vast majority were sensitive. At least two populations have exhibited five-way multiple resistance to the tested herbicide modes of action (MOAs). For EPSPS, none of the known resistance conferring mutations were found, however, an increase of 4-13 copies was observed in the *EPSPS* gene. In ALS-resistant population, Trp-574 to Lue mutation was found in the *ALS* gene. The PS II-resistant plants had the Ser-264 to Gly mutation in the psbA gene.Development and implementation of best management practices are important to preserve the continued utility of the herbicide options that are still effective.

MULTIPLE HERBICIDE RESISTANT RAGWEED PARTHENIUM (*PARTHENIUM HYSTEROPHORUS* L.) CONFIRMED IN TEXAS, USA. S. Singh*[1], V. Singh[1], N. Subramanian[1], J. McGinty[2], M. V. Bagavathiannan[1]; [1]Texas A&M University, College Station, TX, [2], College Station, TX (175)

ABSTRACT

Ragweed parthenium (*Parthenium hysterophorus* L.) is an emerging weed problem in parts of South Texas, and anecdotal evidence suggests potential occurrence of biotypes resistant to glyphosate, atrazine and paraquat. Bioassays were conducted in the greenhouse at Texas A&M University, College Station, TX to evaluate 30 parthenium biotypes collected from the Lower and Upper Gulf Coast regions of Texas. Seedlings (4-6 leaf) were treated with recommended field rates (1X) of glyphosate (868 g ae ha^{-1}), atrazine (1120 g ai ha^{-1}) and paraquat (560 g ai ha^{-1}). Initial screening was followed by a dose-response assay with eight rates (0.125, 0.25, 0.5, 1, 2, 4, 8, and 16X) for one highly resistant parthenium population and six rates (0.125, 0.25, 0.5, 1, 2, and 4X) for the susceptible population (SUS). The experiment was conducted twice in a completely randomized design with 3 replications and 15 plants per replication. Injury was recorded at 21 days after treatment (DAT) for glyphosate and atrazine and at 3 and 14 DAT for paraquat. At the 1X rate of glyphosate, 46% (14 out of 30) of the populations were completely controlled; 23% had an average injury of 85%; and the remaining 31% had survivors with injury ranging from 35 - 75%. None of the populations were completely controlled with atrazine (1X); four populations had 75-85% injury and the remaining 26 populations had an average of 40% injury. Among the populations treated with paraquat, only two were controlled with about 98 and 90% injury at 3 and 14 DAT, respectively, whereas an average of only 35 (3DAT) and 15% (14 DAT) injury was observed in the remaining 28 populations. The dose-response assays have shown that the GR and paraquat-resistant populations were 40- and 36-fold more resistant, respectively, compared to the susceptible standard. Further, a relative increase of 4-17 copies was observed in the 5-enolpyruvylshikimate-3-phosphate synthase (*EPSPS*) gene for 9 GR populations, but none of the previously known resistance conferring mutations were found in them. Therefore, it is likely that *EPSPS* gene amplification is primarily responsible for resistance in the GR parthenium populations evaluated in this study. Future research will focus on determining the level of resistance to atrazine, and understanding the mechanism of resistance to atrazine as well as paraquat in this species.

DISTRIBUTION OF HERBICIDE RESISTANT PALMER AMARANTH (*AMARANTHUS PALMERI*) IN ROW CROP PRODUCTION SYSTEMS IN TEXAS. V. Singh*[1], R. Garetson[1], P. A. Dotray[2], M. V. Bagavathiannan[1], S. Singh[1]; [1]Texas A&M University, College Station, TX, [2]Texas Tech University, Lubbock, TX (176)

ABSTRACT

A state-level survey was conducted across major row-crop production regions of Texas to document the level of sensitivity of Palmer amaranth to glyphosate, atrazine, pyrithiobac, tembotrione, fomesafen, and dicamba. A total of 137 to 161 Palmer amaranth populations were evaluated for sensitivity to the labelled field rate (1X), and rated as resistant (≤ 49% injury), less sensitive (50 to 89% injury), or susceptible (90 to 100% injury). For glyphosate, 62, 19, 12.5, and 12.5% of the populations from the High Plains, Central Texas, Rio Grande Valley, and Lower Gulf Coast, respectively, were resistant. Resistance to atrazine was more common in Palmer amaranth populations from the High Plains than in other regions, with 16% of the populations resistant and 22% less sensitive. About 90% of the populations from the High Plains that exhibited resistance to atrazine POST also were resistant to atrazine PRE. Of the 160 populations tested for pyrithiobac, about 99% were resistant or less sensitive, regardless of the region. No resistance was found for fomesafen, tembotrione, or dicamba. However, 22% of the populations from the High Plains were less sensitive to 1X (93 g ai/ha) tembotrione, but killed at 2X, illustrating the background variability in sensitivity to this herbicide. For dicamba, three populations, all from the High

Plains, exhibited less sensitivity at the 1X rate (controlled at the 2X rate; 1X = 560 g ae ha^{-1}). One population exhibited multiple resistance to three herbicides with distinct mode of action (MOA) involving ALS-, EPSPS-, and PSII-inhibitors. Palmer amaranth populations exhibited less sensitivity to about 15 combinations of herbicides involving up to five MOAs. Dose-response assays conducted on the populations that were the most resistant to glyphosate, pyrithiobac, or atrazine have showed that they were 30-, 32-, or ≥49-fold resistant to these herbicides, respectively, compared to a susceptible standard. Target-site resistance is found to be the mechanism responsible for EPSPS-, ALS- and PSII-inhibitors resistance. For EPSPS, a relative increase of 38-158 copies was observed in the *EPSPS* gene whereas none of the known resistance conferring mutations were found. In ALS-resistant population, analysis of the *ALS* gene revealed the presence of Pro-197 to Thr and/or Trp-574 to Lue mutations. The PS II-resistant plants had the Ser-264 to Gly mutation in the psbA gene.

"GROW": A SCIENCE BASED RESOURCE TOOL FOR INTEGRATED WEED MANAGEMENT. C. G. Rubione*[1], M. J. VanGessel[1], M. L. Flessner[2], S. B. Mirsky[3], M. V. Bagavathiannan[4], L. M. Lazaro[5], K. B. Pittman[2]; [1]University of Delaware, Georgetown, DE, [2]Virginia Tech, Blacksburg, VA, [3]USDA-ARS, Beltsville, MD, [4]Texas A&M University, College Station, TX, [5]Louisiana State University AgCenter, Baton Rouge, LA (177)

ABSTRACT

Weed management has always been challenging, but the recent evolution and spread of herbicide-resistant biotypes has added additional management considerations. Integrated weed management (IWM) is a multi-tactic approach for controlling herbicide-resistant weeds while minimizing the risk of new herbicide-resistant biotypes and stopping the spread of current infestations. IWM allows growers to use **multiple tactics (chemical, cultural, mechanical, biological, and prevention)** to manage weeds**, and in turn improving management of herbicide-resistance biotypes and overall weed control**.

GROW, is a web-based resource for IWM providing science-based information to manage herbicide-resistant weeds as well as other problematic weeds. Understanding weed behavior is a key starting point. This website provides users with information on weed biology and ecology for key weed species, as well as Apps for identification and scouting material. Website users will have direct access to a variety of resources to develop integrated weed management programs for their specific needs.

Two new Apps are being developed for GROW. One will help farmers and dealers select herbicides base on both effectiveness and rotation of herbicide mechanism of action. The second App is an integrated approach for Palmer Amaranth Management (PAM). In addition, state extension websites, newsletters, Ag journals, scientific papers, and a broad range of tactics adapted to various regions of the country are available in the ***"Weed Management Toolbox"*** tab.

GROW's main objective is to promote and increase IWM adoption. It is committed to providing resources to help farmers and crop advisors to develop their own suite of sustainable weed management practices.

GROW is a first step towards "Getting Rid of Weeds" through Integrated Weed Management.

http://integratedweedmanagement.org/

UNDERSTANDING COVER CROP EFFECTS ON WEED SIZE INEQUALITY AT TIME OF HERBICIDE EXPOSURE. J. M. Wallace*[1], W. S. Curran[2], D. Mortensen[1]; [1]Penn State University, University Park, PA, [2]Penn State University, Bozeman, MT (178)

ABSTRACT

Variation in the size of individuals within an emerged weed population at the time of post-emergent herbicide use is likely to influence the intensity of selection pressure for herbicide resistance evolution. In most plant populations, relatively few individuals contribute most of the population's biomass (i.e., size inequality), which results from interactions between age differences, genetic variation, heterogeneity of resources and intraspecific competition. At a post-emergent herbicide application, large individuals intercept less herbicide per biomass unit, which results in greater survival fitness compared to smaller individuals. Large individuals are also likely to be more fecund and will have a disproportionate effect on the gene pool of successive generations. Studies have demonstrated that weed size at the time of herbicide exposure can influence selection intensity for weed biotypes that evolve non-target site resistance mechanisms such as reduced herbicide translocation or enhanced metabolism. We conducted field experiments to evaluate the effect of fall-sown cover crops on size inequality of horseweed (*Erigeron canadensis*L.) at the time of a pre-plant burndown herbicide application in 2014-2015 at Penn State's Russell E. Larson Agricultural Research Center (PSU-RELARC) in central PA. Cover cropping treatments were evaluated following small grain production and were imposed as a RCBD with a split-plot and four replications. Main plots were cover crop treatments: no cover, cereal rye (134 kg ha^{-1}), spring oats (134 kg ha^{-1}), cereal rye + hairy vetch (67 + 22 kg ha^{-1}), cereal rye + forage radish (67 + 6 kg ha^{-1}), spring oats + hairy vetch (67 + 22 kg ha^{-1}), and spring oats + forage radish (67 + 6 kg ha^{-1}). Split-plots were fertility treatments: 0 or 67 kg N ac^{-1}using AMS. Cover crops were planted using a no-till grain drill on 19-cm row spacing following burndown and fertilizer applications in early September. Cover crops were terminated at the cereal rye boot stage (Zadok 45) using glyphosate + 2,4-D (1.26 + 0.56 kg ha^{-1}) and soybean was planted across the study. Prior to planting cover crops, locally-collected horseweed seed was distributed in permanently marked microplots (0.50 m^2) at an average rate of 5,400 seeds m^{-2}. The diameter of ten randomly sampled horseweed plants was measure in each plot and size inequality was 1) visually evaluated using relative frequency distribution plots and 2) statistically compared with the use of unbiased Gini coefficients, which is a summary statistic drawn from Lorenz curves. In both years of the experiment, cereal rye alone significantly reduced the size inequality of horseweed populations compared to the fallow control and cereal rye + hairy reduced size inequality reduced size inequality compared to the fallow control in the second year. Frequency distribution plots showed that significant reductions in size inequality resulted from constraining populations to smaller individuals. Experimental results suggest that winter hardy cover crops can be employed as a management tactic to constrain horseweed populations to small individuals at the time of herbicide exposure, which has important implications for maintaining control efficacy and reducing selection pressure on currently effective modes-of-action available for horseweed management.

CROP ROTATION INFLUENCE ON MAIZE PRODUCTIVITY AND WEEDS. M. Z. Brankov*[1], G. Kruger[2], V. D. Dragicevic[1], M. S. Simic[1]; [1]Maize Research Institute, Belgrade, Serbia, [2]University of Nebraska-Lincoln, North Platte, NE (179)

ABSTRACT

Crop rotation is simple and cheap part of an IWMS. Anyway, besides all know advantages and benefits, it is still not widely used in maize production. Rotation also gives possibility to rotate herbicides with different mode of action, avoiding creation of weed resistance to herbicide phenomena. The aim of this research was to test benefits of maize growing in crop rotation with winter wheat compared to maize continious cropping. Field trial was conducted at MRI Zemun Polje in 2009, and till now four cycles of maize/wheat rotations were realised. Weeds were controlled with mixture of isoxaflutole and s-metolachlor, applied in recommended doses.

After the first cycle, benefits of crop rotation were observed through higher maize grain yield in crop rotation in comparison to maize continuous cropping. Besides the huge impact of meteorological conditions, in every next cycle significantly higher maize grain yield were observed compared to maize continuous cropping. What is more, interaction of crop rotation with herbicide application provided excellent results in weed suppression compared to maize crop grown without rotation. After the first rotation outstanding effects of applied treatments on weediness were confirmed. Significant decrease of total weeds number and their biomasses was observable when compared to treatments with continuous maize growing. In next three rotation cycles, almost no weeds were present in treatments with herbicide combinations, compared to treatments with maize in continuous cropping. The experiment is still on-going, giving opportunity to compare long-term results, in regard to impact of climate alterations.

ACTION MECHANISM OF BLEACHING HERBICIDE CYCLOPYRIMORATE: A NOVEL HOMOGENTISATE SOLANESYLTRANSFERASE INHIBITOR. T. Hamada*, M. Shino, Y. Shigematsu, K. Hirase, S. Banba; Mitsui Chemicals Agro, Inc., Mobara-shi, Chiba, Japan (180)

ABSTRACT

Cyclopyrimorate, 6-chloro-3-(2-cyclopropyl-6-methylphenoxy) pyridazin-4-ylmorpholine-4-carboxylate, was invented by Mitsui Chemicals Agro Inc. and has proven to be highly effective against weeds in rice fields, including those resistant to ALS inhibitors. Furthermore, cyclopyrimorate shows synergistic effects with 4-HPPD inhibitors, such as pyrazolynate. In this study, the action mechanism of cyclopyrimorate was investigated. Cyclopyrimorate caused bleaching symptoms in *Arabidopsis thaliana* similar to those caused by existing carotenoid biosynthesis inhibitors, mesotrione and norflurazon. However, cyclopyrimorate treatment resulted in a significant accumulation of homogentisic acid and a remarkable reduction of plastoquinone. A metabolite of cyclopyrimorate, des-morpholinocarbonyl cyclopyrimorate (DMC), was detected in plants. These data suggested that cyclopyrimorate and/or DMC inhibit homogentisate solanesyltransferase (HST), a downstream enzyme of 4-hydroxyphenylpyruvate dioxygenase in the plastoquinone biosynthesis pathway. *In vitro* assays showed that *A. thaliana* HST was strongly inhibited by DMC and weakly by cyclopyrimorate, whereas other commercial bleaching herbicides did not inhibit HST. DMC derivatives showed a positive correlation between HST inhibition and *in vivo* bleaching activities. These results indicate that the target site of cyclopyrimorate and DMC is HST, which represents a novel target site of commercial herbicides. We have been applying to register cyclopyrimorate in a new classification on mode of action at HRAC. Cyclopyrimorate is expected to offer a new strategy for the management of herbicide resistance in rice fields.

ACTIVE INGREDIENT EFFECTS ON ITALIAN RYEGRASS (*LOLIUM MULTIFLORUM*) CONTROL IN MISSISSIPPI CORN (*ZEA MAYS* L.). M. T. Wesley*[1], J. A. Bond[2], D. B. Reynolds[3], E. J. Larson[4], J. Ferguson[3]; [1]Mississippi State University, MS State, MS, [2]Delta Research and Extension Center, Stoneville, MS, [3]Mississippi State University, Mississippi State, MS, [4]Mississippi State University, Starkville, MS (181)

ABSTRACT

Michael Wesley

WSSA 2019 Abstract-AI study

A field study to determine the effects of active ingredient selection on the efficacy of preemergence herbicides for Italian ryegrass (*Lolium perenne ssp. multiflorum*) in corn (*Zea mays* L.) was conducted from November 2017 to August 2018 at Mississippi State University. The study was conducted at the Black Belt Research Station in Brooksville, Mississippi and was a Randomized Complete Block design. This study consisted of 17 preplant herbicide programs. Applications of seven different fall applied residual herbicides were followed by either a January clethodim (Select Max) plus a February paraquat (Gramoxone SL 2.0) application or a February paraquat application only. Three of the programs did not include a fall applied residual herbicide. Italian ryegrass emergence ratings were taken seven, 14, 28, and 56 days after each herbicide application to assess herbicide efficacy. This study was conducted using a four-nozzle boom sprayer at 4.3 km h^{-1}, a carrier volume of 140 L ha^{-1}, and a pressure of 276 kPa. Plots measured three by nine meters, and corn was planted on raised beds with 97 cm spaced rows on April 6th, 2018. Corn development was assessed throughout the growing season by obtaining plant height measurements and leaf chlorophyll readings. Corn was harvested on August 6th, 2018, and yield was recorded and analyzed. The highest yielding treatment was sprayed with *S*-metolachlor plus atrazine (Cinch ATZ) in the fall and paraquat in February, and averaged 12,479 kg ha^{-1}. The lowest yielding treatment, the untreated check, averaged 5,042 kg ha^{-1}. Four of the five lowest yielding treatments did not receive a fall residual herbicide application. This data shows the importance of residual herbicide use in regards to Italian ryegrass control in Mississippi corn production. This study is currently being replicated and will conclude with the 2019 corn harvest.

ON A KNIFE EDGE: CONSERVATION AGRICULTURE AND TROUBLESOME WEED CONTROL. A. Price*; USDA-ARS, Auburn, AL (182)

ABSTRACT

EVALUATION AND CHARACTERIZATION OF A PROPANE BASED FLAMING SYSTEM FOR WEED CONTROL IN ONION *(ALLIUM CEPA)*. R. N. Lati*[1], Z. Peleg[2]; [1]Agricultural Research Organization, Newe Ya'ar Research Center, Kfar Tavor, Israel, [2]The R.H. Smith Institute of Plant Science & Genetics in Agriculture,

Faculty of Agriculture, Food and Environment, The Hebrew University of Jerusalem, Rehovot, Israel (183)

ABSTRACT

HERBICIDE RESISTANCE GENE FLOW IN WEEDS: UNDER-ESTIMATED AND UNDER-APPRECIATED. H. J. Beckie*[1], R. Busi[2], M. V. Bagavathiannan[3]; [1]University of Western Australia, Crawley, WA, Australia, [2]University Western Australia, CRAWLEY, Australia, [3]Texas A&M University, College Station, TX (184)

ABSTRACT

Interest in the magnitude and consequences of intra- and inter-specific herbicide resistance gene flow, particularly that mediated by pollen, increased in the mid-1990s with the introduction of herbicide-resistant (HR) transgenic crops. During that time, less attention was paid to the movement of HR alleles via pollen or seed among weed populations. Incidence of HR weeds in a region is often attributed to independent evolution through herbicide selection; the role or contribution of HR allele movement via seeds and pollen is often under-estimated and under-appreciated. Once a new HR weed biotype has been confirmed in a jurisdiction, how often have we been surprised at its rapid areawide expansion? In genotypic studies of HR weed populations, the contribution of gene flow to incidence of resistance is often similar or greater than that of independent evolution. Simulation models have consistently predicted that frequent applications of highly effective herbicides (e.g., acetolactate synthase inhibitors, glyphosate) provide connecting 'high-fitness' habitats across the landscape, which facilitates a rapid increase in the frequency and movement of an HR trait within and among populations. The unanticipated speed of area expansion of some HR weed biotypes has spurred numerous calls over the past decade for a collective community or regional response to mitigate this unhindered spread of HR alleles. The best mitigation strategy is reduced weed population abundance in fields and adjacent ruderal areas by minimising seed bank replenishment. This goal is difficult, but necessary for preservation of the remaining common pool resource of herbicide susceptibility.

INHIBITIONS OF PIGWEED *(AMARANTHUS PALMERI S.)* GERMINATION AND GROWTH BY COVER CROP RESIDUES. A. Shekoofa*, S. Safikhan, T. Raper, L. E. Steckel, S. Butler, D. Copeland; University of Tennessee, Jackson, TN (185)

ABSTRACT

Can allelopathic effects of cover crop species play role in management of palmer amaranth/pigweed (*Amaranthus palmeri S.* Watson)? The contributions of cover crop species through their allelopathic impacts to weeds management is not clearly defined. Therefore, during summer 2018, a series of laboratory experiments was conducted at the West Tennessee Research and Education Center (WTREC) in Jackson, TN to study the allelopathic effects of cover crop extracts on germination and seedling growth of pigweed. Extracts from above-ground biomass of five single-species cover-crops (oats, winter pea, rye, vetch, and wheat) and a multi-species blend of cover crop from 4 different termination timings (planting, 6 wks. prior to planting, 3 wks. prior to planting, and furrow termination 6 wks. prior to planting with the remainder terminated at planting of cotton) were tested at 0, 25, and 50 v/v on pigweed seeds (*Amaranthus palmeri S.* Watson). Germination percentage, germination rate, root length, and fresh weight of seedlings were affected by cover crop extracts. Among all five tested cover crop species, the 50 v/v extract treatment from winterpea inhibited germination of pigweed seeds the most (22%). Wheat (6%) and rye (4%) showed the lowest allelopathic impact on pigweed germination. Overall, the suppression of pigweed seeds germination increased with increasing the cover crop extract concentration's levels. Among the termination timings, 6 wks. prior to planting showed the lowest allelopathic effects of a multi-species blend of cover crops on pigweed germination. Also, root and shoot lengths were affected by cover crop extracts in both experiments. Results indicate that cover crop species and cover crop termination timings will play an important role in reducing pigweed seeds germination and root length due to their release of allelochemicals.

HERBICIDES AT RISK: A GLOBAL PERSPECTIVE. C. Mallory-Smith*[1], N. R. Burgos[2], C. Maneechote[3]; [1]Oregon State University, Corvallis, OR, [2]University of Arkansas, Fayetteville, AR, [3]Department of Agriculture, Bankok, Thailand (186)

ABSTRACT

Weeds are usually the most difficult-to-manage pest in crop and noncrop areas. Herbicides continue to be the most frequently used method to manage weeds. Herbicides as well as other pesticides are under greater public scrutiny and criticism. Globally there have been calls to ban herbicides such as glyphosate. Negative views of herbicides often are based, for a multitude of reasons, on information from non-scientific media. Scientific information is generally not readily accessible to the public, the public does not know where to look, or the public does not always have the capability to filter sources of information for veracity. The fact that scientific parlance often is circuitous and difficult to understand does not provide easy access to data that would help inform views. The ecological, sociological, and economic risks of banning the use of certain herbicides are not well understood. In this symposium, we will examine globally important herbicides that have been banned, or are at risk of being banned. The objectives are to: 1) convene leaders of regional and national weed science societies to obtain a common understanding of facts; 2) produce a streamlined set of easy to understand educational materials about herbicides and their need in agriculture; and 3) project a common, science-based message pertaining to the banning of herbicides.

THE DOSE MAKES THE POISON: EXPOSURE TO GLYPHOSATE. K. R. Solomon*; University of Guelph, Guelph, ON (187)

ABSTRACT

Several pesticides have been banned the last 50 years. For the most part, these bans, such as the use of DDT in agriculture, have been based on evidence of harm in the environment. The recent classification of glyphosate as a probable human carcinogen by the International Agency for Research on Cancer (IARC) was a major departure from evidence-based decision making that led to bans on its use in several countries. However, in arriving at its conclusion of category 2A, IARC did not use data from high-quality studies in support of registration; they only used studies from the published literature (one of which they misinterpreted) and they did not consider the basic principle toxicological risk assessment, exposure. IARC's lack of rigorous science was not repeated by regulatory agencies in the US, the EU, and many other jurisdictions, who consider all the data on agrochemicals, including industry studies and exposure. As glyphosate is the most widely used herbicides in the world, one might expect that there would be exposures of applicators and the general public. To test the null hypothesis that exposures to glyphosate were less that levels of concern, exposures via air, water, food, and application of glyphosate were estimated from information published in the open literature as well as unpublished reports provided by Monsanto Company. Even for potentially highly exposed sub-populations, systemic doses resulting from exposures to glyphosate were less than the reference dose and the acceptable daily intakes proposed by several national and two international regulatory agencies and the null hypothesis was not falsified. This supports a conclusion that even for highly exposed populations, exposures are within recently updated regulatory limits and there is no scientific evidence to support that banning of glyphosate.

ENVIRONMENTAL FATE AND ECOLOGICAL IMPACT OF GLYPHOSATE. S. O. Duke*; USDA-ARS-NPURU, Oxford, MS (188)

ABSTRACT

Glyphosate is the most used herbicide worldwide, and there have been concerns about its environmental impact. Compared to most other herbicides, the half-life of glyphosate in soil and water is relatively short (averaging about 30 days in temperate climates), mostly due to microbial degradation. Its primary microbial product, aminomethylphosphonic acid, is slightly more persistent than glyphosate. In soil, glyphosate is virtually biologically inactive due to its strong binding to soil components. Glyphosate does not bioaccumulate, largely due to its high water solubility. Glyphosate-resistant crops have greatly facilitated reduced tillage agriculture, thereby reducing soil loss, soil compaction, carbon dioxide emissions, and fossil fuel use. Agricultural economists have projected that loss of glyphosate would result in increased cropping area, some gained by deforestation, and an increase in environmental impact quotient of weed management. Some drift doses of glyphosate to non-target plants can cause increased plant growth (hormesis) and/or increased susceptibility to plant pathogens, although these non-target effects are not well documented. The preponderance of evidence confirms that glyphosate does not harm plants by interfering with mineral nutrition and that it has no agriculturally significant effects on soil microbiota. The preponderance of data support the view that glyphosate has a lower environmental impact quotient than most synthetic herbicide alternatives.

GLYPHOSATE BAN IN THE EU - CONSEQUENCES AND CHALLENGES. S. K. Mathiassen*, P. Kudsk; Aarhus University, Slagelse, Denmark (189)

ABSTRACT

S.K. Mathiassen, P. Kudsk, Aarhus University, Slagelse, Denmark.

The EU pesticide regulation is one of the strictest in the world. It is currently based on two legislative acts: Regulation 1107/2009 on the 'Placing on the Market of Plant Protection Products' and Directive 128/2009 on the' Sustainable Use of Pesticides'. Regulation 1107/2009 stipulates seven cut-off criteria that lead to a ban (carcinogenic, mutagenic, toxic for reproduction, persistent, bio-accumulative and toxic for the environment, persistent organic pollutants, very persistent and very bio-accumulative and endocrine disruptive). Opportunities for exemptions exist; the use of a hazardous substance can be approved in a limited period not exceeding five years if, on basis of documented evidence, '*it is necessary to control a serious danger which cannot be contained by any other available means*' (Reg. 1107/2009, Art. 4 (7)). The EU pesticide regulation aims to phase out the chemicals of concern by substituting them with safer alternatives providing a list of 'candidates for substitution' for which comparative assessments of potential alternatives are required.

The process of reviewing active substances on the European market began 25 years ago, and since then the number of approved active substances has decreased by more than 50%. One of the main pillars of the current regulations is to focus on hazard rather than risk. This principle recently turned the renewal process for glyphosate into a cliffhanger for European farmers. The scientific assessment process carried out by the selected member states and the 'European Food Safety Authority' concluded that glyphosate *'is unlikely to pose carcinogenic hazard to humans'*. At the same time, a report from the 'International Agency for Research on Cancer' classified glyphosate as *'probably carcinogenic'*. Glyphosate renewal went through several votes in the 'Standing Committee of Plant, Animals, Food and Feed' with no decisive conclusion reached. Finally, a vote in favour of renewal for a period of 5 years was passed by the Appeal Committee and subsequently adopted by the Commission. Restrictions on the pre-harvest use of glyphosate and the use in public spaces were introduced in several member states.

Glyphosate is the most frequently used herbicide in Europe, despite the fact that no GM crops are grown. In annual crops it is used pre-sowing to reduce the need for soil cultivation and selective post-emergence herbicides, as a pre-harvest treatment to control perennial weeds, surviving annual weeds and aid harvest and post-harvest in the stubble to clean up. Glyphosate is increasingly viewed as an important tool to combat herbicide resistance. Glyphosate is also used in perennial crops and on non-cultivated areas. Glyphosate controls a broad range of weeds, including many perennial weeds, and has a wide application window, making it a unique herbicide that cannot be replaced by any other herbicide or any non-chemical, weed control measure. Changes in cultivation practices over the last two decades, including more winter cereals in the crop rotations and adoption of minimum tillage, have led to a heavy reliance on glyphosate. Several reports have analyzed the consequences of the loss of glyphosate on European agriculture. In summary, they conclude that a ban will have a significant negative economic impact. It will force European farmers to redesign their farming practices and to include more mechanical and labour intensive methods to control weeds. Land, currently under minimum tillage, will have to be turned back to inversion cultivation, requiring extra cultivation passes and extra herbicide applications to achieve effective weed control. A shift to more spring cropping (to allow more time for soil tillage) is likely. Increasing operational costs (machinery, labour and fuel) and declining yield and crop quality are expected to reduce profit margins. The environmental costs of a loss of glyphosate include the increased use of other herbicides, more soil erosion, soil compaction and increased CO_2 emissions.

THE BANNING OF BROMACIL IN COSTA RICA. B. E. Valverde*; Investigación y Desarrollo en Agricultura Tropical, Alajuela, Costa Rica (190)

ABSTRACT

Bromacil was introduced at the beginning of the 1960s for the pre- and early post-emergence control of grasses and broadleaf weeds, particularly in citrus orchards and pineapple plantations as well as in non-cultivated areas. Both the acidic form of bromacil and its lithium salt are highly soluble in water; the herbicide is moderately to highly persistent in the soil with a half-life ranging from 60 days to eight months and is prone to percolate in the soil and reach ground water. In Costa Rica, bromacil was registered for both citrus and pineapples but in recent years its major use was in the second crop. An average 60 metric tons of bromacil active per year were imported prior to its banning in 2017. Pineapple is grown in over 40000 ha; the recommended rate of bromacil was 1.6 to 3.2 kg ha^{-1}. In a survey conducted by the National University between 2001 and 2004, bromacil was the most frequently found pesticide, at levels between 0.5 and 20 $\mu g\ L^{-1}$, in water springs and wells in the pineapple growing area of the Caribbean side of Costa Rica. Further studies conducted more recently also documented the presence of bromacil in the ground and surface water in areas where pineapple is planted. The local standard for the quality of drinking water of 2015 established maximum acceptable values of 0.1 $\mu g\ L^{-1}$ and 0.5 $\mu g\ L^{-1}$ for a single pesticide and for the sum of all pesticides present, respectively, but it was amended for bromacil to comply with requirements determined by the Constitutional Court to "non-detectable by method." A historical account and the scientific and administrative considerations for the banning of bromacil on 24 May 2017 will be presented in detail.

A OVERVIEW OF PESTICIDE BAN AND RESTRICTED USE IN BRAZIL AND SOUTH AMERICA. E. R. Camargo*[1], L. A. Avila[1], M. Zapiola[2]; [1]Federal University of Pelotas, Pelotas, Brazil, [2]Pontifical Catholic University of Argentina, buenos aires, Argentina (191)

ABSTRACT

Brazil and Argentina are the primary South America grain producers. In the region, especially in Brazil, agriculture is performed under tropical conditions where pesticides are critical for crop protection. Presentation will focus on herbicide that are been banned or are under restricted use in the region. Particular attention will be

given to paraquat, glyphosate and auxinics.

TOXICOLOGY AND THE IMPACT OF PARAQUAT BAN ON HUMAN POISONING. D. KIM*; Seoul National University, Seoul, South Korea (192)

ABSTRACT

Paraquat (1,1'-dimethyl-4,4'-bipyridium dichloride) is a highly effective non-selective herbicide showing the fastest weed control activity among all the herbicides registered and currenly approved for use in around 90 countries. However, due to its high toxicity to humans and lack of effective antidoes for those who are exposed to paraquat intentionally, accidentally or occupationally, the paraquat is associated with a high mortality rate and has become the most common herbicide causing suicide death, resulting in 20 per million persons dying from paraquat as a suicide method worldwide. For this reason, the use of paraquat has been banned in over 50 countries such as the European Union and many Asian countries including Korea. A recent study to investigate the impact of paraquat ban on human poisoning and suicide death in Korea revealed that paraquat ban resulted in decreased suicide rate by 10% and 46.1% for total suicides and suicides by pesticides (mainly paraquat), respectively. The case of Korea demonstrates that paraquat ban led to a lower rate of suicide by paraquat poisoning but also a reduction in the overall suicide rate, suggesting that paraquat ban can be considered as a national strategy to lower suicide. In this presentation, the impact of paraquat ban on economic aspects will also be discussed.

BAN OF HERBICIDES: THE CASE OF GLYPHOSATE IN SRI LANKA. B. Marambe*; University of Peradeniya, Peradeniya, Sri Lanka (193)

ABSTRACT

In Sri Lanka, N-(phosphonomethyl) glycine (glyphosate) was introduced in 1978 for weed control in the non-crop lands in tea plantations. The herbicide was recommended for crop land in tea in 1988 and for pre-plant weed control in paddy in 1998. The import of glyphosate formulations (36% a.i.) to Sri Lanka reached the peak in 2012 (5 million Liters), Assuming that the product was uniformly distributed over agricultural area of the country, the average annual use of glyphosate a.i. is only 0.9 kg/ha, showing a 45-60% lower use than the global average. From the glyphosate-based herbicides imported to Sri Lanka, tea cultivation has consumed the highest (29%) quantity followed by maize (23%), paddy (17%) and vegetables (14%). On an average, 60-70% of the rice farmers and 58-69% of maize and Other Field Crops (OFC) growers, and all major tea plantations and about 50% of the tea smallholders have used glyphosate for weed control over the years.

In 2014, the government of Sri Lanka restricted the use of glyphosate, together with few other pesticides, in the areas country affected by the non-communicable disease 'Chronic Kidney Disease of Uncertain Etiology' (CKDu) of the country. This was based on the assumption that glyphosate had a role in the etiology of CKDu. However, the disease was first reported in Sri Lanka in early 1990's, especially in the paddy-growing areas in the north central province, even prior to the official recommendation of the use of glyphosate as a pre-plant weed control in paddy. In 2015, a total ban of import and use of the herbicide was imposed in Sri Lanka due to various allegations related to human and environmental health. Consequently, two Extra-ordinary Gazette Notifications banned the import and use of the product under the Imports and Export (Control) Act No 1 of 1969 (as amended), and cancelled the import licenses issued under the Control of Pesticides Act No 33 of 1980 (as amended). These decisions made without an effective alternative, has negatively affected the food security and national economy of Sri Lanka, especially due to aggravated weed problems in maize, tea and paddy cultivations further increasing the problems created by climate change, labor shortage, fertilizer issues, and increased cost of crop production. The ban has also triggered the heavy use of more hazardous and non-recommended herbicides and promoted smuggled products thus, aggravating the damage to the quality of agricultural produce exported, and the human and environmental health.

After a lapse of three years since imposition of the total ban on glyphosate, the government of Sri Lanka rescinded the order in 2018 for a period of 36 months through two Extra-ordinary Gazette Notifications. The gazette issued by the Registrar of Pesticides of Sri Lanka cited "the interest of the public and on the advice of the Pesticides Technical and Advisory Committee" as the main reason. Further, the Cabinet of Ministers of Sri Lanka has approved the import of glyphosate based formulations through selected suppliers and provide only to the tea and rubber plantations through state infrastructure. The paper presented will further elaborate on the direct and indirect impacts of the ban of glyphosate in Sri Lanka.

CANCELED REGISTRATION OF HERBICIDES IN ISRAEL AFFECTS WEED DISTRIBUTION AND MANAGEMENT. B. Rubin*[1], H. Eizenberg[2]; [1]Hebrew University of Jerusalem, Rehovot, Israel, [2]Farmers Valley Center, Migdal Haemek, Israel (194)

ABSTRACT

Pesticide registration in Israel is a laborious and lengthy process involving approval by an Advisory Committee composed by representatives of four governmental Ministries led by the Ministry of Agriculture, through its arm – The Plant Protection and Inspection Services (PPIS). The other representatives come from the Ministry of Health, the Ministry of Labor and the Ministry of Environmental Protection. Being a small country, no new pesticide is registered in Israel unless it is already approved and registered by at least one major western country. The implementation of the new EU directive 1107/2009 in Europe requested re-evaluation and re-registration of all pesticides, resulted in a massive ban of numerous active ingredients (AI), and their removal from the market. Likewise, the Israeli authorities (PPIS) canceled the registration of the triazine herbicides- simazine and ametryn and severely restricted the use of atrazine, terbutryn and prometryn (2012-2013). The absence of the residual simazine products for weed control in roadsides and orchards, resulted in over-reliance on glyphosate products, shifted the structure of weed population in this habitats ending up with troublesome weeds (new for orchards) and a massive evolution of glyphosate-resistant weeds such as *Conyza bonariensis*. Trifluralin use that was banned on 2015, resulted in a significant increase in small-seed broadleaf weeds such as *Amaranthus* spp., field bindweed (*Convolvulus arvensis*) and grass weeds such as barnyard grass (*Echinocloa column*) and Johnson grass (*Sorghum halepense*), in many irrigated row crops. At present, 49 pesticide AIs (including 19 herbicides), registered in Israel but not registered in Europe, are under the PPIS revision process awaiting decision. The impact of the potential ban of these herbicides on weeds and their management will be discussed.

RISK ANALYSIS OF POSSIBLE GLYPHOSATE BAN IN EU ON TURKISH HAZELNUT PRODUCTIONS AND ECONOMY . H. Mennan*; Ondokuz Mayıs University, ATAKUM, Turkey (195)

ABSTRACT

Risk analysis of possible glyphosate ban in EU on Turkish hazelnut productions and economy

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Hazelnut (*Corylus avellana* L.) is native to the Black Sea coast of Turkey as a shrub on the steep slopes of the mountains and in the plain. Turkey is the largest hazelnut producing and exporting country in the world, followed by Italy, Spain, USA, and Greece. Hazelnut is not only one of the most important export crops of Turkey, but also a key factor in maintaining social, economic, and environmental sustainability in the rural and urban parts of the region. Glyphosate is very effective tools for controlling many perennial troublesome weed species in hazelnut. The registration period within the EU due to expire at the beginning of 2023. Within the scope of the research, a different number of surveys carried out according to planted area of hazelnut to understood how possible glyphosate ban will effect on hazelnut production and economy. Sixty farm survey was done randomly along the Black sea region and those data used primary sources. However, the database of institutions, thesis, reports, and articles used as secondary data sources to find the possible effect of glyphosate ban on Turkish hazelnut production and economy. One of the most important findings of the study was, agriculture business and employment sustained by hazelnut production constitute a significant part of the rural economy in the region. The potential ban of glyphosate will effect control of *Rubus canariensis (blackberry), Artemisia vulgaris (mugwort) and Smilax aspera (common smilax) due to lack of systemic herbicides in the market*. In the case of a ban, tillage and mechanical strategies are the most suitable methods for controlling those weeds. But, mechanical control suppresses of those weeds not as efficiently as herbicides and may cause further spread. There are two alternatives to obtain the same weed control levels as same as glyphosate, one of them is the diquat application and the other is a mechanical control. But, the cost of those methods is 80% expensive than glyphosate. The cost-benefit model predicted that total hazelnut production will decrease by 12-21% due to weeds not controlled well. Reducing yields under a glyphosate ban would most probably drive prices further up. Glyphosate ban would result in a reduction in Turkish GDP. Yearly, an average of $ 2 billion in revenue is obtaining from hazelnut exports and this figure corresponds to 1.37% of Turkey's annual exports. The glyphosate ban will cause 240-420 $ million loss in hazelnut export and 66.000 and 115.500 tons in yield. We assume that global demand for hazelnut will increase because world production depends largely on Turkey. Consequently, costly exporting practices and lack of product may influence global industry which the sector is using as processing raw material. As a consequence, companies may relocate processing materials from hazelnut to other nuts. Over the short term, the possible ban may increase the demand for labor due to higher shares of mechanical strategies.

Keywords: Possible glyphosate ban, hazelnut production, alternative weed control strategies, economic effects

THE GOOSEGRASS (*ELEUSINE INDICA*) GENOME RESOLVES HOMEOLOGOUS GENE RELATIONSHIPS WITHIN ALLOTETRAPLOID CROP PLAN AFRICAN FINGER MILLET (*ELEUSINE CORACANA*). N. Hall*, J. D. Patel, J. S. McElroy, L. R. Goertzen; Auburn University, Auburn, AL (196)

ABSTRACT

Several crop plants (e.g. Secale cereale) have weedy origins. The sequencing and phylogenetic analyses of weedy and crop genomes offers a powerful tool for understanding the transitions from wild to weedy to domesticated a process typified by Vavilovian mimicry. Weed genomics offers insight into the contributions of Vavilovian mimicry to the process of domestication and the subsequent success and function of current crop plants and their distinctive genetics. Here we take the case of a weedy diploid (AA) parent Eleusine indica (goosegrass) and its domesticated allotetraploid (AABB) daughter E. coracana (African finger millet) and assign genomic scaffolds to either A or B genomes, show the relationship of the A and B genomes within the genus Eleusine and characterize gene expression based on homeologous pairs.

From scaffold analysis, we are able to identify A and B scaffolds and show examples of homeologous crossover. Using synonymous substitution rates among syntenic genes and a genome guided orthology approach to phylogenomics, we show that origin of the B genome is within the genus Eleusine. Finally, using 22 transcriptomes we identify an interesting region of low expression with in the A genome. Weed genomics has lately emerged as a powerful new tool for the advancement of weed control in agriculture and other heavily managed systems, but its utility in areas like crop improvement and understanding the history of crop domestication is under exploited.

CRITICAL TIME FOR WEED REMOVAL IN CORN AND SOYBEAN AS INFLUENCED BY PRE-HERBICIDES. S. Z. Knezevic*[1], O. Osipitan[2], J. E. Scott[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Concord, NE (197)

ABSTRACT

Understanding the critical time for weed removal (CTWR) in corn and soybean would not only ensure effective weed removal and minimize unnecessary weed control inputs, but could potentially help minimize the development of herbicide resistance in weeds. Field experiments were conducted in 2017 at Concord, Nebraska, to evaluate the influence of pre-emergence (PRE) herbicides on CTWR in glyphosate-resistant corn and soybean. The studies were arranged in a split plot design; 3 herbicide regime (Without PRE and PRE application of two herbicides) as main plots, and 7 weed removal timings relative to growth stages of the crops, as subplots. The two PRE herbicides in corn were Atrazine (2240 g ai ha^{-1}) and Acuron® (atrazine + bicyclopyrone + mesotrione + S-metolachlor, 2890 g ai ha^{-1}). While in soybean, the two PRE herbicides were Authority Assist® (sulfentrazone + imazethapyr, 280 g ai ha^{-1}) and Zidua PRO® (saflufenacil + imazethapyr + pyroxasulfone, 215 g ai ha^{-1}). The CTWR was generally delayed by the use of PRE herbicide, based on 5% acceptable yield loss. In corn, without PRE herbicide, the CTWR started at V3 growth stage, while PRE

application of atrazine or Acuron® delayed the CTWR to V5 or V10 growth stage respectively. In soybean, the CTWR started at V1 growth stage, while PRE application of Authority Assist® or Zidua PRO® delayed the CTWR to V6 growth stage. These results suggested that application of PRE herbicides did not only delay the need for post-emergence weed control inputs, it also provided alternative mode of action for weed control in corn and soybean.

IMPROVING MESOSULFURON METHYL PERFORMANCE IN WINTER WHEAT. M. D. Anderson*[1], J. McGregor[2]; [1]BAYER CROPSCIENCE, Spangle, WA, [2], Research Triangle Park, NC (198)

ABSTRACT

Mesosulfuron has been evaluated in combination with other herbicides throughout its development, and has been widely used alone or in various combinations over the past 15 years globally. Propoxycarbazone has been the most common herbicide formulated with mesosulfuron in the U.S. A new combination with thiencarbazone will be offered as Osprey Xtra in 2019. This product has been developed to broaden the weed spectrum of grass and broadleaf weed control over mesosulfuron alone in winter wheat. In Pacific Northwest trials, rattail fescue efficacy improved an average of 35% over mesosulfuron alone. Overall grass and broadleaf weed control increased 10-15% over six years of trial evaluation. Mesosulfuron plus thiencarbazone will have the same wide crop application window of 1 leaf to 2 node as mesosulfuron. Outside of the Pacific Northwest, trial results have indicated about a 10% improvement in downy brome and Italian ryegrass efficacy with the thiencarbazone addition. This product will also contain a higher level of the safener mefenpyr diethyl. Adjuvants and use rates will be similar to mesosulfuron alone allowing an easy transition between these products. Due to the need for an effective postemergence option on rattail fescue in the Pacific Northwest, this combination will initially target the states of WA, OR, and ID.

SEEDING RATE, ROW SPACING AND HERBICIDE EFFECTS ON WEED CONTROL IN PINTO BEAN. D. W. Morishita*, K. D. LeQuia; University of Idaho, Kimberly, ID (199)

ABSTRACT

Previous research has shown advantages of planting pinto bean (*Phaseolus vulgaris* L.) in narrow rows compared to standard rows at the same plant population. Seeding black bean at higher rates in narrow has provided an advantage for weed control. Comparing seeding rates of pinto bean planted in narrow rows has not been evaluated. The objectives of this study were to: 1) determine the optimum dry bean plant population in a narrow row planting configuration for growth and yield; 2) compare five pinto bean plant populations grown in narrow rows to pinto bean grown in standard rows; and 3) compare the weed control in response to pinto bean planted in narrow rows at five seeding rates. The experiment was a 5 x 6 factorial randomized complete block design. The 5 seeding rates were equivalent to 25, 31, 37, 43, and 49 seeds/m^2 in 19-crm rows, plus 1 treatment planted at 25 seeds/m^2 in 56-cm rows. The five weed control treatments consisted of an non-treated control, handweeded control, EPTC + ethalfluralin applied preemergence (PRE), EPTC + ethalfluralin applied PRE followed by dimethenamid-P applied after the first trifoliate growth stage, and EPTC + ethalfluralin applied PRE followed by bentazon + imazamox applied after the first trifoliate growth stage. Bean yield was highest in the handweeded control compared to other weed control treatments in 2016. In 2017, bean yield was higher in the 37 and 49 seed/m^2 rates than in the 25 seed/m^2 rate in 19- or 56-cm rows in 2017. Increased seeding rate in narrow rows is a cultural method that can increase yield in dry pinto bean.

HORSEWEED (*CONYZA CANADENSIS* L.) MANAGEMENT IN OKLAHOMA WINTER WHEAT. M. Manuchehri*[1], J. A. Crose[1], T. A. Baughman[2], J. Childers[1], V. Kumar[3]; [1]Oklahoma State University, Stillwater, OK, [2]Oklahoma State University, Ardmore, OK, [3]Kansas State University, Hays, KS (200)

ABSTRACT

Quelex® (halauxifen + florasulam), Sentrallas® (thifensulfuron + fluroxypyr), and Talinor® (bromoxynil + bicyclopyrone) are three relatively new postemergence premix herbicides developed for control of broadleaf weeds in winter wheat. These herbicides along with older products were evaluated for their control of horseweed (*Conyza canadensis* L.) in Oklahoma in the spring of 2017 and 2018. Visual weed control was estimated every two weeks throughout the growing season and wheat yield was collected from three of the six site years. Horseweed size at time of application ranged from 5 to 20 cm. Across all site years, halauxifen + florasulam achieved greater than 90% control with the exception of two treatments at Altus in 2018 and one at Ponca City in 2018. Thifensulfuron + fluroxypyr + dicamba achieved greater than 90% control at all site years except at Ponca City in 2017. However, when MCPA replaced dicamba in this mixture, control at all site years decreased. Halauxifen + florasulam and thifensulfuron + fluroxypyr were both effective at controlling a wide range of horseweed rosette sizes across all locations while control with other treatments varied and depended on presence of herbicide resistance, weed size at time of application, and tank mix partners.

MANAGEMENT OF GRASS WEED SPECIES WITH SOIL-APPLIED HERBICIDES IN COOL-SEASON GRASSES GROWN FOR SEED. A. G. Hulting*[1], D. W. Curtis[2], K. C. Roerig[2], C. Mallory-Smith[2]; [1]OREGON STATE UNIVERSITY, Corvallis, OR, [2]Oregon State University, Corvallis, OR (201)

ABSTRACT

OPTIMIZING CHLOROACETAMIDE PLACEMENT IN COTTON PRODUCTION SYSTEMS. S. Davis*[1], D. Dodds[2], L. X. Franca[2], J. P. McNeal[3], B. Norris[1], J. J. Williams[1]; [1]Mississippi State University, Starkville, MS, [2]Mississippi State University, Mississippi State, MS, [3]Mississippi State University, Mississippi State, Mississippi, MS (202)

ABSTRACT

DEVELOPING A LASER WEEDING ROBOT FOR WEED CONTROL IN BROAD-SCALE PRODUCTION SYSTEMS. G. R. Coleman*, M. J. Walsh; University of Sydney, Narrabri, Australia (203)

ABSTRACT

The place of herbicides in effective weed control is being challenged by herbicide resistance, increasing public concern and reduced development of new modes of action. However, concurrent with this challenge has been the advancement in autonomous functionality, sensor capability and processing power, a key driver of renewed research and development of alternative weed control methods. Numerous physical and thermal weed control methods are available, yet many lack commercial presence and in-depth evaluation, so how do we know where to begin? Physical and thermal alternate weed control options, while lacking a reliable cost, all share a value for energy consumption and are thus comparable on this basis. Using published data, the energy requirements for the effective control of 2-leaf stage weed seedlings were determined for a range of weed control options including herbicides, when applied as broadcast (whole field), or site-specific treatments. The site-specific approach to weed control resulted in substantially lower energy consumption for herbicidal (92%), thermal (99%) and mechanical (93%) treatments, dependent on weed density. These results identified several options, potentially equivalent in cost to herbicides and with broadacre relevance resulting from improved technology. Of those identified, laser weeding was selected as an alternative option suited for use in various cropping systems, on a range of robotic and autonomous platforms. Subsequently, preliminary research has commenced on the use of lasers for point-specific weed control, investigating duration, spot size and energy intensity. Thanks to technological advances the opportunity now exists for the site-specific use of lasers and other innovative approaches for weed control in broadscale cropping systems.

IMPACT OF INCREASING LEVELS OF IRRIGATION ON WEED CONTROL AND CORN YIELD WITH AND WITHOUT A WHEAT COVER CROP. R. Currie*, P. Geier; Kansas State University, Garden City, KS (204)

ABSTRACT

A killed winter wheat (*Triticum aestivum* L.) cover crop (CC) under limited irrigation has increased corn yield despite the opportunity cost of the water used to grow it (Weed Science, 2005, 53: 709-716). Furthermore, this research showed that a CC can improve weed control. In that study, only two levels of irrigation were possible. Therefore, the main objective of this research was to measure yield and weed control under a broad range of irrigations with and without a killed winter wheat CC. The experimental design was a randomized complete block with four replications in a split-plot arrangement. The main plot factor was irrigation level and CC was sub-plot factor. Six irrigation levels (100, 75, 50, 25, 15, and 0% of full evaporative demand) within each replication were used. Each irrigation level was split into a winter wheat CC portion planted in the fall prior to spring planting and a no CC portion. A wk before corn planting in the spring of 2014, a tank mixture consisting of glyphosate + S-metolachlor + mesotrione + atrazine at 1.4 + 2 + 0.2 + 0.78 kg ha^{-1} was applied over the entire plot area to kill the winter wheat CC and to provide the pre-emergence herbicides for subsequent corn crop. This experiment was repeated in 2015, 2017 and 2018. A planter malfunction in 2017 rendered the after planting data useless. Prior to corn planting, the CC produced a 5- to 20-fold reduction in kochia (*Bassia scoparia* L.) in all years and produced 7- and 31-fold reduction in Russian thistle (*Salsola tragus* L.) in two years and 100% control in 2017 and 2018. Common lambsquarters (*Chenopodium album* L.) was only present in two years and was controlled at 20- and 169-fold prior to corn planting. Averaged over levels of irrigation, CC increased corn yields in all years between 8 and 48% with an average increase of 1857 kg ha^{-1}. The CC often elevated yield in 2014 and 2015, however, this elevation was only significant at the levels greater than 25% of evapotranspiration (ET) and most often at levels higher than 75% of ET. In 2014, yield was described by the equation kg ha^{-1} = 61.1 * % ET + 2184 with a CC (R^2 = 0.76) and kg ha^{-1} = 46.2 * % ET + 1258 in the absence of a CC (R^2 = 0.83). In 2015, although yields across irrigation levels were higher in the presence of CC with a slope of 0.34 for cover and 0.09 for no cover, response to irrigation was less pronounced (R^2 < 0.43). In 2018, although CC yields were higher than no-CC yields across irrigation rates, the slopes of these lines were nearly identical; 0.91 and 0.92 for cover and no-cover, respectively. A linear response to level of irrigation was seen in 2018 with R^2 of 0.91 and 0.83 for cover and no-cover, respectively. This suggests that yields might have been less variable in the presence of a CC. These results confirm previous work (Weed Science, 2005, 53: 709-716) and show that the benefits of a killed winter wheat CC to yield and weed control extend over a broad range of moisture conditions but are most pronounced at higher levels of irrigation.

WEED STRESS EFFECTS OF COVER CROPS IN EARLY CORN GROWTH STAGES. J. M. Miller*, S. A. Clay, D. E. Clay, G. Reicks, D. Joshi; South Dakota State University, Brookings, SD (205)

ABSTRACT

Cover crops provide diverse benefits to corn production and overall soil health. However, major challenges of adopting cover crops in South Dakota environments include plant establishment, species selection, soil moisture management, and cover crop termination. Also, if not managed properly, cover crops may compete with corn for limiting resources that can cause negative effects on growth and ultimately reduce yield. Our objectives were to: a) identify cover crops that grow and produce biomass in a corn system; and b) examine the stress effects of cover crops especially during early corn growth stages. This study used rye (*Secale cereal* L.) and radish (*Raphanus sativus* L) as cover crops and was conducted at the South Dakota State University experimental area in Aurora, SD. Cover crops were drill planted at the same time as corn planting at distances of 15 or 30 cm from the corn row, and at a rate of 23 kg/ha (rye) and 4 kg/ha (radish). Cover crops were terminated when corn was at the V4 growth stage. Rye and radish biomass averaged 1.6 and 3.3 g/m of row, and 2.6 and 6.3 g/m of row at the 15 cm and 30 cm spacing, respectively. At V4, soil moisture, soil available nitrogen, and corn leaf chlorophyll were similar among treatments. But corn grown with rye at 15 cm row width had 40% less biomass per plant and was 15% shorter compared with the control. At V8 stage, corn grown with cover crops was generally shorter, by an average of 9%, compared with the control. In this experiment cover crops grew and produced biomass until V4 corn without affecting yield. Although cover crops may have caused stress condition that affected early corn growth, end-of-season grain yield was similar among treatments.

THE IMPACT OF COVER CROP BIOMASS AND C:N RATIO ON EARLY-SEASON WEED SUPPRESSION. K. B. Pittman*, J. Barney, M. L. Flessner; Virginia Tech, Blacksburg, VA (206)

ABSTRACT

Summer annual weeds reduce crop yield through competition. Terminated cover crop residue can create a mulch layer that has the ability to suppress summer annual weed emergence. The slower this cover crop degrades, the longer weed suppression is possible. Research was conducted to evaluate summer annual weed suppression from cover crop monocultures and mixtures and to correlate cover crop biomass and quality metrics, such as carbon-to-nitrogen (C:N) ratio, to summer annual weed suppression.

Studies were conducted in Blacksburg and Blackstone, Virginia from 2015 to 2017. These studies were set up as a randomized split-split block design with four replications. Treatments consisted of four cover crop species: cereal rye, forage radish, hairy vetch, and crimson clover in monoculture and mixtures. A no cover crop control was also included. Cover crops were drilled in late September to mid-October for all site years and terminated in late April to early May using a roller crimper and glyphosate at 1.26 kg ae ha^{-1}. At termination, above ground biomass was taken and samples were dried and analyzed for carbon and nitrogen content. Quality metrics of the cover crop mixture treatments were determined by using the mass determination from the biomass samples to determine a weighted average of the components. Cash crops were planted two weeks after termination, which split the cover crop main plot into corn and soybean blocks. These blocks were further split again by weed management: no weed management versus a typical herbicide program for each cash crop. Visible weed control ratings were taken on a two-week basis, starting 4 weeks after termination (WAT), using a 0 (no suppression) to 100 (complete suppression) scale as compared to the nontreated check. Corn and soybean yield data were collected at the end of the season. Data were analyzed using JMP Pro 14. For the cover crop components and crop yield, data were subjected to ANOVA followed by means separation using Tukey's $HSD_{(\alpha=0.05)}$. Logistic regressions of weed suppression ratings 6 WAT were used to determine correlations between quantity and quality metrics and weed suppression. Forage radish winterkilled across all site-years and was excluded from the analyses.

Biomass between cover crop treatments ranged from 3,600 to 9,000 kg ha^{-1} with cereal rye and cereal rye containing mixtures accumulating greater biomass than hairy vetch or crimson clover alone. C:N ratio followed the same trend with hairy vetch and crimson clover having the lowest C:N ratio (12:1 and 17:1, respectively) and cereal rye alone having the greatest C:N ratio (36:1). In Blacksburg, redroot pigweed and pitted morningglory were the predominant weed species across both years while large crabgrass was present for all site years. To achieve 85% control of redroot pigweed 6 WAT, a cover crop would need to obtain 8,000 kg ha^{-1} and have a C:N ratio of 34:1, at termination. Cover crops achieving similar biomass and C:N ratio would not achieve the same level of suppression for pitted morningglory or large crabgrass at the same level, 6 WAT. No differences in corn or soybean yield could be detected in plots treated with a herbicide program meaning that the cover crop treatments did not affect weed-free yield.

COVER CROP RESPONSE TO RESIDUAL HERBICIDES IN PEANUT AND COTTON ROTATION. K. J. Price*[1], S. Li[1], A. Price[2]; [1]Auburn University, Auburn, AL, [2]USDA-ARS, Auburn, AL (207)

ABSTRACT

Cover crops can provide many benefits to peanut and cotton rotation in terms of suppressing weeds, conserving soil moisture for planting, increasing soil organic matter, and reducing soil erosion. However, in fields where residual herbicides were used during the growing season, establishment of cover crops can be negatively affected by the herbicide residues. The objective of this study was to investigate the responses of six cover crops (daikon radish, cereal rye, cocker oats, crimson clover, winter wheat, and common vetch) to twelve common soil herbicides used in peanut and cotton. A multi-year (2016-2018), multi-location study was conducted in Macon and Henry County in Alabama. Herbicide treatments were applied at 10% of full labelled rate for cotton or peanut at cover crop planting. At 50 and 150 days after planting (DAP), plant heights and stand counts were evaluated as well as wet biomass at 150 DAP. Treatments included *S*-metolachlor, acetochlor, pyroxasulfone, diclosulam, imazapic, chlorimuron ethyl, bentazon plus acifluorfen, pyrithiobac sodium, trifloxysulfuron sodium, diuron, prometryn, flumioxazin, and a non-treated check (NTC). In 2016, significant stand reductions (p0.05) of 30-52% in rye and 22-75% in wheat respectively were observed at 50 DAP for *S*-metolachlor, acetochlor, pyroxasulfone, diclosulam, imazapic, chlorimuron ethyl, and bentazon plus acifluorfen over both locations. Vetch had significant stand reductions for all twelve treatments at 50 DAP ranging from 12-80% over both locations. *S*-metolachlor, pyroxasulfone and acetochlor had the largest negative impacts on stand counts for rye, wheat and vetch. Daikon radish had significant height reductions of 9, 15, and 31% at 50 DAP for diuron, chlorimuron ethyl, and imazapic, respectively, in Macon County. At 145-149 DAP, all affected cover crops had recovered from herbicide damage and did not show any significant treatment differences in any of the growth parameters evaluated in 2016. In 2017, wheat had a significant stand reduction of 22% for flumioxazin at 42-45 DAP over both locations. At 147-149 DAP, clover had a significantly reduced stands of 29-38% for diclosulam and trifloxysulfuron sodium respectively, over both locations. Radish also had a significantly reduce stand of 64% for diclosulam. Oats, rye and vetch did not have any significant stand reductions at either timing in 2017/2018. Oats showed the most tolerance with no treatments significantly reducing stands or plant heights for either year. Overall, the type of cover crop planted should be based on the residual herbicides applied to row crops the previous season as well as the biomass goal and nutrient needs of the field. Although initial injury and stunting may occur, biomass of those cover crops may not be affected by herbicide residues evaluated in this study.

IMPLICATIONS OF NARROW CROP ROW SPACING AND DELAYED AVENA FATUA AND AVENA LUDOVICIANA EMERGENCE FOR WEED GROWTH AND SEED PRODUCTION IN WHEAT. B. S. Chauhan*, G. Mahajan; The University of Queensland, Gatton, Australia (208)

ABSTRACT

Avena fatua and *A. ludoviciana* are problematic weed species in winter cropping systems in Australia. A field experiment was conducted in the winter season of 2018 to determine growth and seed production of *A. fatua* and *A. ludoviciana* emerging at five intervals (0, 2, 4, 6 and 8 weeks after wheat emergence, WAWE) in wheat planted at 25- and 50-cm row spacing. Plant height of both species was not influenced by the crop row, but it was influenced by the weed emergence time. Height was highest for the weed plants emerging with the crop plants. Both species emerging with the crop had greater biomass and seed production under 50-cm rows, but row spacing had no effect on biomass and seeds of plants emerging later in the crop. Weed plants that emerged 8 WAWE produced 11-14 seeds/plant in 50-cm rows, whereas only 2-4 seeds/plant were produced by these plants in 25-cm rows. At harvest, higher seed shattering (79-89%) was observed for *A. fatua* compared with *A. ludoviciana* (22-30%) for the weed plants emerging with the crop. These results suggest that *A. ludoviciana* could be targeted using harvest weed control methods but most seeds of *A. fatua* may escape these control techniques. The results also suggest that narrow row spacing and early weed control could be important components of integrated weed management strategies in wheat.

ON-FARM ASSESSMENT OF WEED MANAGEMENT AND PRODUCTIVITY OF DRY-SEEDED RICE IN THE IRRIGATED RICE-WHEAT CROPPING SYSTEM. M. S. Bhullar*[1], N. Dhaliwal[2], J. Grover[3], K. Kaur[4], A. Kaur[5], M. Singh[6], S. Chopra[7], H. Singh[8], M. Kaur[1]; [1]Punjab Agricultural University, Ludhiana, India, [2]Punjab Agricultural University, Sri Muktsar Sahib, India, [3]Punjab Agricultural University, Faridkot, India, [4]Punjab Agricultural University, Amritsar, India, [5]Punjab Agricultural University, Moga, India, [6]Punjab Agricultural University, Sangrur, India, [7]Punjab Agricultural University, Gurdaspur, India, [8]Punjab Agricultural University, Fatehgarh sahib, India (209)

ABSTRACT

Labour scarcity, increasing labour costs and declining ground water table have forced farmers in Punjab state of India to find an alternative to resource intensive puddle hand transplanted rice (PTR). Dry-seeded rice (DSR) was introduced in 2010 to address these problems in rice cultivation. In DSR, weed flora tends to be more diverse and weeds emerge in several flushes during the crop growth cycle and yield reductions due to weed competition are quite common. DSR was compared with PTR at farmers' field at total of 224 locations (plot size 4000m^2) during four years, 2014, 2015, 2016 and 2017, in Indian Punjab. The shift from PTR to DSR rapidly changed the weed spectrum to aerobic grass weeds viz. *Dactyloctenum aegyptium, Leptochloa chinensis* and *Eragrostis* sp. from typical rice weeds *Echinochloa crus-galli* and *Panicum colonum,* and to perennial sedge *Cyperus rotundus* from annual sedges *Cyperus iria* and *Cyperus difformis*. The DSR fields needed 2 to 4 herbicide applications compared to 2 to 3 in case of PTR. In DSR, fenoxaprop-p-ethyl gave effective control of aerobic grass weeds and metsulfuron-methyl plus chlorimuron-ethyl of perennial sedge and broadleaved weeds, along with conventional rice herbicides pendimethalin and bispyribac-sodium. Averaged over all locations and years, DSR gave 2.9% less rice grain yield than PTR however economic returns from DSR were similar or higher than from DSR; DSR had appreciable savings in human labour (14 person days/ha) and irrigation water (10-20%) than PTR. The results indicated that DSR has potential to produce grain yield equivalent to PTR provided weeds are managed effectively. Further improvements in planting machinery and weed management practices, promotion of DSR only in medium to heavy texture soils and enhancement of farmers' skills through hands-on trainings were identified as the key areas for accelerating DSR adoption at scale.

INFLUENCE OF CARRIER VOLUME, NOZZLE TYPE, AND WEED SIZE ON GLUFOSINATE EFFICACY. J. Calhoun*[1], D. B. Reynolds[2]; [1]Mississippi State University, Starkville, MS, [2]Mississippi State University, Mississippi State, MS (210)

ABSTRACT

Field studies were conducted over a two year time period (2017 and 2018) in Starkville, MS to evaluate the influence carrier volume and weed size at application have on weed control efficacy of glufosinate when applied using two different drift reduction nozzles. Glufosinate was applied at rates of 0.66 kg ai ha^{-1} and 0.88 kg ai ha^{-1} using TTI and TDXL nozzles. Treatments were applied at 140 L ha^{-1} and 94 L ha^{-1} to weeds 8 and 15 cm in height. Plots were evaluated for weed control and crop injury every seven days until 28 days after treatment. No significant crop injury was recorded from any treatment. Averaged across both rates, control of *Amaranthus tuberculatus* (AMATU) increased 8% or greater at all ratings when glufosinate was applied at weed sizes of 8 cm compared to 15 cm. AMATU control was the same for treatments applied using TTI and TDXL nozzles at seven days after application. At 14, 21, and 28 days after application, treatments using a TDXL resulted in a 5 to 6% increase in weed control compared to TTI treatments. At all ratings, treatments applied at 140 L ha^{-1} resulted in greater weed control compared to 94 L ha^{-1} treatment applications. Therefore, this research suggests to achieve optimum weed control efficacy using glufosinate, timely applications at smaller weed sizes in combination with 140 L ha^{-1} should be utilized. Additionally, when using drift reduction nozzles, TDXL nozzles resulted in greater weed control than TTI.

GLUFOSINATE-RESISTANT ITALIAN RYEGRASS FROM OREGON: ROLE OF GLUTAMINE SYNTHETASE ISOFORMS AND HERBICIDE METABOLISM IN THE RESISTANCE MECHANISM. C. A. Brunharo*[1], H. K. Takano[2], C. Mallory-Smith[1], F. E. Dayan[3], B. Hanson[4]; [1]Oregon State University, Corvallis, OR, [2]Colorado State University, Ft Collins, CO, [3]Colorado State University, Fort Collins, CO, [4]University of California, Davis, Winters, CA (211)

ABSTRACT

Glufosinate-resistant *Lolium perenne* L. spp. *multiflorum* biotypes from Oregon were identified 10 years ago, exhibiting resistance levels up to 2.8-fold the recommended field rate. One biotype (MG) exhibited an amino acid substitution in the enzyme glutamine synthetase 2 (GS2), whereas the other (OR) did not. We hypothesized that the amino acid substitution in GS2 is involved in the mechanism of resistance to glufosinate in MG, and that non-target-site mechanisms of resistance are present in OR. Enzyme activity, gene expression quantification, amino acid quantification, herbicide mobility and stability experiments were performed with MG, OR and a known-susceptible biotype. Our results suggest that glufosinate metabolism is the major mechanism conferring glufosinate resistance to OR, and that an amino acid substitution observed in the GS2 from MG is not involved in the resistance mechanism. These results may be applied to improve management decisions for Oregon crop growers.

CONTROL OF COMMON LAMBSQUARTERS AND VELVETLEAF BY TANK-MIXING GLUFOSINATE AND FLUTHIACET-METHYL IN GLUFOSINATE-RESISTANT SOYBEAN. P. Chahal, A. J. Jhala*; University of Nebraska-Lincoln, Lincoln, NE (212)

ABSTRACT

A field study was conducted at the South Central Agricultural Laboratory near Clay Center, Nebraska in 2017 and 2018 to evaluate the effect of glufosinate and fluthiacet-methyl tank-mixed at different rate combinations for control of common lambsquarters and waterhemp and their effect on yield in glufosinate-resistant soybean. Glufosinate at 594 or 740 g ai ha^{-1} tank-mixed with fluthiacet at 4.8 to 7.2 g ha^{-1} controlled common lambsquarters 84 to 90% and 77 to 95% compared to 14 to 42% and 38 to 56% control with fluthiacet applied alone at 28 DAT in 2017 and 2018, respectively. Common lambsquarters control was later improved to 64 to 83% and 54 to 69% with fluthiacet applied alone all rates at 49 DAT in 2017 and 2018, respectively. Glufosinate at 560 or 740 g ha^{-1} alone or tank-mixed with fluthiacet at 4.0 to 7.2 g ha^{-1} provided similar waterhemp control of 56 to 72% and 69 to 84% compared to 15 to 33% and 19 to 58% with fluthiacet alone at 28 DAT in 2017 and 2018, respectively. Similar results were observed with density reduction of common lambsquarters and waterhemp at 28 DAT during both years. However, biomass reduction of common lambsquarters was similar (73 to 94%) with all glufosinate or fluthiacet rates applied alone or tank-mixed at 28 DAT. Similarly, biomass reduction of waterhemp was similar (76 to 96%) at all glufosinate and fluthiacet rates applied alone or tank-mixed, except 45% reduction at fluthiacet applied alone at 4.8 g ha^{-1}. Glufosinate and fluthiacet tank-mixed combinations resulted in soybean yield of 2,093 to 3,177 kg ha^{-1} which was comparable to glufosinate or fluthiacet applied alone in 2018. Soybean was not harvested in 2017 due to high weed pressure in the plots at the time of harvest. The results suggested that glufosinate and fluthiacet belonging to distinct site of action can be tank-mixed to effectively control common lambsquarters and waterhemp in glufosinate-resistant soybean.

CHARACTERIZATION OF PALMER AMARANTH WITH REDUCED SENSITIVITY TO S-METOLACHLOR. C. Brabham*, J. K. Norsworthy, M. M. Houston; University of Arkansas, Fayetteville, AR (213)

ABSTRACT

Very-long-chain fatty acid (VLCFA)-inhibiting herbicides are foundational for overlapping residuals to control Palmer amaranth in season. This has also inadvertently increased selection for Palmer amaranth with reduced sensitivity or resistance to Group 15 herbicides. In 2016, Palmer amaranth escapes following *S*-metolachlor that was adequately activated with rainfall were noted at several sites in Arkansas. Thus, field and greenhouse experiments were conducted to test for resistance to VLCFA-

inhibiting herbicides in accessions from Crawfordsville and Marion. In the field, a labeled application of acetochlor (1,472 g ai ha^{-1}; EC formulation) and dimethenamid-P (631 g ai ha^{-1}) provided ≥ 94% control of the putative resistance accessions while *S*-metolachlor at 1,064 g ai ha^{-1} only provided 76% control. In the greenhouse, based on LD_{50} values obtained from a dose response experiment, the Marion and Crawfordsville accessions were 9.8 and 8.3X less sensitive to *S*-metolachlor in comparison to the average of two susceptible accessions. *S*-metolachlor at 704 and 1,632 g ha^{-1} was needed to obtain 90% mortality of the Crawfordsville and Marion accessions, respectively, in the greenhouse. In an agar based bioassay, glutathione-S transferases were found to be the primary *S*-metolachlor resistance mechanism in the Marion accession. In regards to other VLCFA-inhibiting herbicides, Marion and Crawfordsville accessions were susceptible to acetochlor, dimethenamid-P, and pyroxasulfone in the greenhouse. However, both accessions did exhibit increased tolerance (1.5- to 3.6-fold based on LD_{50} values of the susceptibles) to the tested VLCFA-inhibiting herbicides. In this study, we report the first case of resistance to *S*-metolachlor in Palmer amaranth.

STATUS OF MULTIPLE HERBICIDE-RESISTANT PALMER AMARANTH IN KANSAS. V. Kumar*[1], R. Liu[1], T. Lambert[2], D. Peterson[3]; [1]Kansas State University, Hays, KS, [2]Kansas State University, hays, KS, [3]Kansas State University, Manhattan, KS (214)

ABSTRACT

Evolution of multiple herbicide-resistant (MHR) Palmer amaranth (*Amaranthus palmeri*) is an increasing problem for producers in the Central Great Plains, including Kansas. A random field survey was initiated in 2014, to determine the distribution of MHR Palmer amaranth across Kansas cropping systems. Seeds of Palmer amaranth plants were collected from corn, sorghum, soybean, sunflower, and chemical-fallow fields, with a total of 175 field populations. Selected (about 30) Palmer amaranth populations were screened in 2018 for multiple resistance to glyphosate, chlorsulfuron, mesotrione, atrazine, 2, 4-D, and dicamba. Seedlings from each selected population were grown in 10- by 10-cm size square plastic pots filled with a commercial potting mix in a greenhouse at Kansas State University Agricultural Research Center (KSU-ARC) near Hays, KS. Experiments were performed in a randomized complete block design in factorial arrangement of treatments (populations by herbicides) with 12 replications and repeated. Actively growing seedlings (7- to 9-cm tall) were separately treated with discriminate dose of glyphosate (1260 g ha^{-1}), chlorsulfuron (52 g ha^{-1}), mesotrione (105 g ha^{-1}), atrazine (560 g ha^{-1}), 2,4-D (870 g ha^{-1}), and dicamba (560 g ha^{-1}). Data on percent visible injury, fresh and dry weights were determined at 21 d after treatment (DAT). Whole-plant dose-response assays were conducted on a putative MHR Palmer amaranth population collected from Barton County, KS. Based on a cut off visible injury (< 85%), resistance to glyphosate, chlorsulfuron, atrazine, and mesotrione was confirmed in 22, 20, 22, and 16 populations, respectively. Seven populations also showed reduced sensitivity to 2,4-D (69 to 82% injury), while all tested populations were highly sensitive to dicamba. Dose-response assays indicated that the putative MHR population had high-level resistance to glyphosate (11.9-fold), chlorsulfuron (17.0-fold), atrazine (17.8-fold); moderate level resistance to mesotrione (7.3-fold) and low-level resistance to 2,4−D (3.5-fold) and fomesafen (2.3-fold). In a separate greenhouse study, alternative herbicides programs, including tank-mixture of dicamba with glyphosate, atrazine, or fluroxypyr + 2,4-D; paraquat alone or tank-mixed with atrazine, metribuzin, saflufenacil, or 2,4-D; saflufenacil alone or tank-mixed with atrazine, metribuzin, or 2,4-D; glufosinate alone or tank-mixed with glyphosate + 2,4-D, and glyphosate + dicamba; and a premix of bicyclopyrone + atrazine + mesotrione + s-metolachlor effectively controlled (≥99% injury) this MHR population. These preliminary results suggest that the resistance to glyphosate, chlorsulfuron, atrazine, and mesotrione is fairly common among Palmer amaranth populations in Kansas. These results also confirm the first report of a Palmer amaranth population with multiple resistance to six herbicide sites of action in Kansas. Growers should utilize alternative herbicides (dicamba, paraquat, saflufenacil, glufosinate alone or in tank-mixtures) for managing MHR Palmer amaranth populations.

INFLUENCE OF SEQUENCE AND TIMING OF SYNTHETIC AUXINS AND GLUFOSINATE ON LARGE PALMER AMARANTH CONTROL. F. B. Browne*, S. Li, K. J. Price; Auburn University, Auburn, AL (215)

ABSTRACT

Evolution of herbicide resistance in Palmer amaranth has created immense challenges for crop production. Residual herbicide applications often fail and Palmer amaranth escapes can be difficult to manage. Consistent control with glufosinate can be achieved if applied when Palmer amaranth is less than 10 cm tall. Unfortunately, rapid growth and adverse weather conditions can complicate timely applications. Glufosinate and synthetic auxin combinations have been shown to provide greater control of Palmer amaranth than when applied alone. Sequential applications of postemergence herbicides can further increase weed control and synthetic auxins followed by a timely application of glufosinate could be beneficial. To test Palmer amaranth control using sequential applications at different time intervals, field trials were conducted in Henry County, AL in 2017 and 2018. Treatments were applied to Palmer amaranth 45 cm tall and herbicides tested were 2,4-D, dicamba, glyphosate, glufosinate, and *S*-metolachlor at 1.06 kg, 559 g, 1.54 kg, 594 g, and 1.47 kg ai ha^{-1}. Single applications evaluated were 2,4-D/dicamba + glyphosate, glufosinate + *S*-metolachlor, and 4-way tank mixtures. Sequential applications included 2,4-D/dicamba + glyphosate followed by (fb) glufosinate + *S*-metolachlor 1 or 3 days after initial treatment (DAIT) in 2017 and 3 or 7 DAIT in 2018. Additionally, sequential applications were tested in reverse sequence at 3 day intervals in 2017 and 7 day intervals in 2018. Visual injury was recorded at 14 and 28 DAIT in addition to height and biomass 35 DAIT. Higher visual injury was observed for all sequential applications of 2,4-D/dicamba fb glufosinate + *S*-metolachlor compared to single applications, 4-way tank mixtures, or reverse sequence applications in 2018. Single applications of glufosinate + *S*-metolachlor did not reduce Palmer amaranth biomass in 2017 and resulted in 65% reductions in 2018 as compared to the non-treated control. Palmer amaranth control with applications of 2,4-D/dicamba + glyphosate alone was sporadic with biomass reductions ranging from 13% to 83%. Four-way tank mixtures (2,4-D/dicamba + glyphosate + glufosinate + S-metolachlor) reduced biomass 11 to 72% in 2017 and 67 to 72% in 2018. In general, control increased with sequential applications of glufosinate + *S*-metolachlor fb 2,4-D/dicamba + glyphosate with biomass reductions of 54 to 68% in 2017 and 71 to 79% in 2018. When the sequence was reversed, 2,4-D/dicamba + glyphosate fb glufosinate + *S*-metolachlor provided even higher control with biomass reductions of 77 to 85% in 2017 and 97 to 100% in 2018. Dicamba + glyphosate fb glufosinate + *S*-metolachlor 7 DAIT resulted in total Palmer amaranth control in 2018. Intervals between applications were most effective for 3 and 7 days compared to 1 day. The data indicate sequential applications of synthetic auxins fb glufosinate are more likely to rescue fields infested with large palmer amaranth than single applications or sequential applications with glufosinate applied first.

MULTIPLE HERBICIDE-RESISTANT HORSEWEED (*CONYZA CANADENSIS* L. CRONQ.) AND WATERHEMP (*AMARANTHUS TUBERCULATUS* MOQ. J. D. SAUER) DOSE RESPONSE TO TOLPYRALATE AND TOLPYRALATE PLUS ATRAZINE. B. A. Metzger*[1], A. J. Raeder[2], D. Hooker[3], D. Robinson[4], P. Sikkema[4]; [1]University of Guelph, Wallenstein, ON, [2]ISK Biosciences, Concord, OH, [3]University of Guelph, Ridge, ON, [4]University of Guelph, Ridgetown, ON (216)

ABSTRACT

Tolpyralate, a recently commercialized herbicide, inhibits the 4-hydroxyphenylpyruvate dioxygenase (HPPD) enzyme in susceptible plants. Applied postemergence (POST), alone or in tank-mixtures with atrazine, tolpyralate provides control of several annual grass and broadleaf weed species in corn. Multiple-resistant (MR) Canada fleabane (Groups 2 and 9), and MR waterhemp (Groups 2, 5, 9 and 14), are an evolving weed management challenge in Ontario. Field studies to examine tolpyralate dose

response in these species, and compare to commercial standard herbicides were conducted in Ontario in 2017/2018 at four locations with populations of MR Canada fleabane, and at three locations with populations of MR waterhemp. Treatments included six rates of tolpyralate from 3.75-120 g ai ha^{-1} applied alone or with atrazine in a 1:33.3 tank-mix ratio. Commercial standards included dicamba/atrazine (1500 g ai ha^{-1}) and bromoxynil + atrazine (280 + 1500 g ai ha^{-1}) for control of MR Canada fleabane, and dicamba/atrazine (1500 g ai ha^{-1}) and mesotrione + atrazine (100 + 280 g ai ha^{-1}) for control of MR waterhemp. At 8 WAA, tolpyralate + atrazine at 22.3 + 742 g ai ha^{-1}, applied POST, controlled MR Canada fleabane ≥95%, similar to both industry standards; however, no dose of tolpyralate alone provided >95% control. At 8 WAA, tolpyralate + atrazine at 57 + 1901 g ai ha^{-1}, applied POST, controlled MR waterhemp ≥95%, similar to both industry standards, while tolpyralate alone did not provide 95% control. These studies conclude that tolpyralate + atrazine provides excellent control of MR Canada fleabane and MR waterhemp, and is an effective herbicide option for in-season management of these species in corn.

PREDICTING THE RELATIVE LONG-TERM EFFECTIVENESS OF HERBICIDE PROGRAMS USING SYNGENTA'S RESISTANCE FIGHTER MODEL. R. Wuerffel*[1], C. L. Dunne[2], E. Parker[1], E. Palmer[3], D. L. Bowers[4], D. Kaundun[5], C. Liu[5]; [1]Syngenta, Vero Beach, FL, [2]Syngenta Crop Protection, Vero Beach, FL, [3]Syngenta Crop Protection, Greensboro, NC, [4]Syngenta, Greensboro, NC, [5]Syngenta, Braknell, England (217)

ABSTRACT

Successful stewardship of weed management tools (herbicides, tillage, cover crops, etc.) requires a focus on weed seed bank management; however, there are numerous logistical and experimental challenges when attempting to address these long-term research questions using traditional field trials. Even more challenging is convincing growers to adopt practices that do not necessarily afford short-term gain, but may reduce soil seed bank densities subsequently providing a potential return on investment after multiple years. Modeling weed management practices can be useful to meet these objectives given that modeling is not limited to time constraints and uncontrollable environmental factors. A generalized individual-based model was developed by Liu et al. (2017) that uses a novel approach for herbicide resistance modeling. In this model, biological parameters influence individual weeds and weed seeds as opposed to influencing the population as a whole. Furthermore, biological parameters such as seed production, emergence time, and quantitative resistance are represented by a range of responses which allows every individual in the model to have a stochastic and unique response, thereby accounting for natural variation. This model has been adapted specifically for *Amaranthus tuberculatus* in corn and soybeans and a user interface was developed to allow for direct interaction with standard computing capabilities.

ECONOMIC IMPLICATIONS OF HERBICIDE RESISTANT WEED MANAGEMENT IN GLYPHOSATE-RESISTANT SUGARBEET. A. T. Adjesiwor*[1], N. C. Lawrence[2], P. Jha[3], T. Gaines[4], E. Westra[4], A. Kniss[1]; [1]University of Wyoming, Laramie, WY, [2]University of Nebraska-Lincoln, Pullman, WA, [3]Montana State University, Huntley, MT, [4]Colorado State University, Fort Collins, CO (218)

ABSTRACT

Glyphosate-resistant (GR) sugarbeet (*Beta vulgaris* L.) have been widely adopted by growers primarily due to the economic benefits. However, the value of this trait is beginning to erode, as new weeds continue to evolve resistance to glyphosate. Field studies were conducted in Wyoming, Montana, Nebraska, and Colorado, to evaluate one component of the economic impact of GR kochia (*Kochia scoparia* (L.) Schrad.) and GR Palmer amaranth (*Amaranthus palmeri* S. Wats.) in GR sugarbeet. Five herbicide programs were applied in a randomized complete block design with six replicates at all locations. Treatments included a weed-free control treatment that was sprayed with only glyphosate, and four herbicide treatments where additional herbicides were added to the glyphosate. These four herbicide treatments were chosen based on our expectation that they would provide the best control possible of GR kochia (2 treatments) and GR Palmer amaranth (2 treatments). For each species, one herbicide program was selected that would provide POST control, and a second herbicide program was selected that would rely on the 'layered residual' concept, where residual herbicides are applied multiple times throughout the season. No glyphosate-resistant weeds were present at any of the four field sites, and therefore, all weeds were well-controlled by the herbicide treatments. This allowed us to quantify sugarbeet injury and yield loss based only on the herbicides being applied, and not confounded by weed competition. When harvested at the 10 to 12 true-leaf stage, and at final harvest, layered residual treatments had less impact on sugarbeet yield and biomass production compared to the POST control treatments. Averaged over sites, the POST herbicide treatment targeting Palmer amaranth reduced sucrose yield by 11%, while the POST herbicide treatment targeting kochia reduced sucrose yield 4%. Additional economic impacts have also been analyzed, but vary with price and cost estimates.

EFFICACY AND ECONOMIC COMPARISON OF ENLIST, XTEND AND LIBERTY BASED WEED CONTROL SYSTEMS IN COTTON. S. A. Nolte*[1], R. Vulchi[2], M. Matocha[3], G. Morgan[2], J. McGinty[4]; [1]Texas A&M AgriLife Extension, College Station, TX, [2]Texas A&M University, College Station, TX, [3]Texas AgriLife Extension Service, College Station, TX, [4], College Station, TX (219)

ABSTRACT

Management of glyphosate resistant weeds has become increasingly difficult due to repeated use of Roundup-Ready technology. Timely applications are a must in achieving adequate control of resistant weeds. Along with the use of residual products at planting and as tank mix partners for in-season applications, there is a need for alternative herbicide technologies that employ multiple effective modes of action to control current herbicide resistant species and manage against the development of new resistant weed species. Cotton system such as XtendFlex, Enlist, and Liberty-Link, provide options to maximize weed control when used properly. However, providing sound weed management recommendations that growers will adopt requires evaluating the weed control benefits as well as the associated costs of each herbicide system. For these reasons, a cotton systems comparison study was conducted in 2018, in College Station, Texas. The study employed sequential herbicide applications in XtendFlex, Enlist, and Liberty-Link cotton that were evaluated for their effectiveness for weed control, subsequent yield and net profit. At harvest, across the three technologies, Palmer amaranth (*Amaranthus palmeri*) control ranged between 80.25% and 100%, Colorado grass (*Texas panicum*) control ranged between 92% and 100% and Sharp pod morning glory (*Ipomea cordatotriloba*) control ranged between 84% and 94%.

INVESTIGATION OF *CONYZA CANADENSIS* CONTROL IN KENTUCKY NO-TILL SOYBEAN ACROSS THREE HERBICIDE RESISTANT SOYBEAN VARIETIES. T. R. Legleiter*[1], J. Green[2]; [1]University of Kentucky, Princeton, KY, [2]University of Kentucky, Lexington, KY (220)

ABSTRACT

The increasing presence of glyphosate and ALS-resistant horseweed in Kentucky and newly emerging herbicide-resistant soybean genetics has generated a need for research evaluating horseweed control. Field experiments were conducted in a randomized complete block design with four replications at two locations in Kentucky in

2017 and 2018. Herbicide programs to target horseweed consisting of either an early preplant foliar (EPP) or preplant foliar (PPF) burndown application followed by a post-emergence (POST) treatment were evaluated on three different soybean traits: glyphosate-resistant, glyphosate- and dicamba-resistant, and glufosinate-resistant. Herbicide treatments were applied with a 3m boom at a spray volume of 140 L ha^{-1} with a CO_2 propelled backpack or an ATV sprayer. Herbicide programs in the glyphosate-resistant soybean that contained saflufenacil applied as a PPF burndown resulted in 89% or greater control at the Versailles location both years and in Princeton in 2017. Horseweed that ranged in size from 60 to 91 cm at PPF in Princeton in 2018 resulted in 59% or less control for all programs regardless of herbicide. Glufosinate-resistant programs that involved glufosinate applied PPF showed greater than 94% control at all sites and years. EPP treatments that included dicamba or saflufenacil resulted in 75% or greater control. Herbicide programs that incorporated dicamba or glufosinate in the PPF burndown application had effective control and would be recommended to help control horseweed in soybean varieties containing traits tolerant to these herbicides. Programs that rely only on glyphosate as a PPF treatment and POST application did not provide effective horseweed control. The inclusion of saflufenacil in the PPF burndown was the only consistently effective horseweed control program in the glyphosate-resistant soybean system when applied to appropriately sized horseweed.

ON-FARM EVALUATIONS OF AUXIN NOZZLES FOR PEANUT PEST MANAGEMENT. E. P. Prostko*[1], M. R. Abney[2], R. C. Kemerait[2], G. C. Rains[2], J. L. Jacobs[3], C. T. Powell[4], W. G. Tyson[5]; [1]University of Georgia, Tifton, GA, [2]The University of Georgia, Tifton, GA, [3]The University of Georgia, Blackshear, GA, [4]The University of Georgia, Colquitt, GA, [5]The University of Georgia, Statesboro, GA (221)

ABSTRACT

In 2018, approximately 81% of the cotton acres grown in Georgia were planted using XtendFlex® varieties. One of the requirements for the use of dicamba on Xtendflex® cotton varieties is that growers must use nozzle/pressure combinations that produce very-coarse to ultra-coarse droplets ($VMD_{50} \geq 404$ microns). Since most cotton growers are also peanut growers, there is much interest in using "auxin" nozzles for pest management in peanut. However, there is concern that these coarse droplet nozzles might not be adequate for the multitude of pesticides applied in peanut that have traditionally required maximum coverage. Therefore, large-plot, replicated, on-farm peanut field trials were conducted in 2018 to compare the performance of flat fan nozzles to auxin nozzles using commercial application equipment. Trials were conducted in 3 counties including Bulloch, Miller, and Pierce. In Bulloch Co., a JD4630 applicator (90' boom) calibrated to deliver 15 GPA (25 PSI, 12.6 MPH) was used to compare XR-11006 and TADF06-D nozzles. In Miller Co., a JD4030 applicator (110' boom) calibrated to deliver 10 GPA (24 PSI, 10 MPH) was used to compare XRC-11005 and TTI60-11005 nozzles. In Pierce Co., a JD4730 applicator (100' boom) calibrated to deliver 16 GPA (23 PSI, 11.6 MPH) was used to compare XR-11006 and TTI-11006 nozzles. All agri-chemicals, including herbicides, fungicides, insecticides, and fertilizers routinely used by the grower, were applied with either nozzle type. All data were subjected to ANOVA and means separated using Tukey's HSD (P=0.10). No differences in weed, insect, or disease control between nozzle types were observed at any location except for threecornered alfalfa hopper [*Spissistilus festinus* (Say)] in Miller Co. Threecornered alfalfa hopper populations were higher in plots treated with the TTI60 nozzle. No differences in peanut yield were observed between nozzle types at any location (P>0.30).

GRAMOXONE MAGNUM: A NEW OPTION FOR BURNDOWN AND RESIDUAL CONTROL . R. Lins*[1], M. Saini[2], D. L. Bowers[3]; [1]Syngenta Crop Protection, Rochester, MN, [2]Syngenta Crop Protection, Greensboro, NC, [3]Syngenta, Greensboro, NC (222)

ABSTRACT

Gramoxone Magnum herbicide is a new product for burndown and residual control of grass and broadleaf weeds in corn, legume vegetables, sorghum, soybeans, and sunflower. Gramoxone Magnum is a combination of paraquat (Group 22) and s-metolachlor (Group 15). Upon EPA approval, it will provide two alternative sites of action to glyphosate (Group 9) and has tank mix flexibility for multiple cropping systems.

RESEARCH RESULTS ON A FUTURE RESIDUAL HERBICIDE FOR DICAMBA-TOLERANT SOYBEANS. C. Asmus*[1], K. E. Keller[2]; [1]BASF, Raleigh, NC, [2]BASF, Rougemont, NC (223)

ABSTRACT

FEDERAL RESEARCH AND ITS LINKAGE WITH THE USEPA AQUATIC HERBICIDE REGISTRATION PROCESS. K. D. Getsinger*[1], C. R. Mudge[2], B. T. Sartain[1], M. Netherland[3]; [1]U.S. Army Engineer Research and Development Center, Vicksburg, MS, [2]U.S. Army Engineer Research and Development Center, Baton Rouge, LA, [3]University of Florida, Gainesville, FL (224)

ABSTRACT

Only three herbicides received Section 3 USEPA labels for use in aquatic sites over a 25-year period: glyphosate (1977), fluridone (1986) and triclopyr (2002). Yet, during this same time, the spread of invasive aquatic and wetland weeds increased dramatically, along with an acute awareness and need for viable control options. This conundrum was driven by a number of factors. The cost of the registration process can be considerable ($10-40 million), but aquatic sales are estimated at only $100-150 million per year in the US, a relatively minor share of the overall pesticide market. Major changes in USEPA requirements, such as the registration review procedure, sometimes complicated and slowed the entire process. Additional state regulatory and permitting processes, NPDES requirements, and the negative perception of pesticide use by the public placed more complexity and burdens on aquatic registrations. Also, the short patent life of a molecule, combined with the introduction of generic products, discouraged development of proprietary aquatic products. The combination of these factors resulted in a low return on investment for potential registrants. In addition, the critical interactions among the research community, the registrants, and the regulatory community had been greatly diminished. All three groups had lost in-house technical expertise, having experienced downsizing due to reduced budgets, and had lost the interactive communication required to secure an aquatic label. However, over the past 15 years, a public-private-academic partnership emerged that has revolutionized the aquatic registration landscape. Led by scientists at the US Army Engineer Research and Development Center, cooperators including Federal and state agencies representing R&D, operations, and regulatory functions (e.g. US Army Corps of Engineers Districts, USEPA-OPP, US Bureau of Reclamation, USDA-CSREES IR-4 Project, USDA-ARS, USDA-APHIS), academic institutions (e.g. University of Florida, LSU, NC State, Mississippi State, UC-Davis, Colorado State, Clemson, and Washington State), and non-profit research organizations, such as the Aquatic Ecosystem Restoration Foundation (AERF). These collaborative efforts have produced various aquatic labels (some with reduced risk

status) for new compounds such as imazapyr, carfentrazone-ethyl, imazamox, penoxsulam, bispyribac-sodium, flumioxazin, tompramezone, and florpyrauxifen-benzyl, and supported the re-registration of the legacy chemicals 2,4-D, endothall, diquat and copper. In addition, invasive plant liaison positions, Subject Mater Experts (SMEs), via the US Army Corps of Engineers, the AERF, and the WSSA closely interact with the UESPA-OPP. These SMEs play a critical role in elucidating the need for, and use patterns of, herbicides associated with invasive plant management in aquatic sites. Clearly, this linkage of multi-faceted, third-party partnerships with the aquatic herbicide registration process represents a key aspect for managing invasive plants in our Nation's waterways.

CONCENTRATION AND EXPOSURE TIME REQUIREMENTS OF FLORPYRAUXIFEN-BENZYL FOR MANAGING INVASIVE AQUATIC PLANTS. C. R. Mudge*[1], K. D. Getsinger[2], B. T. Sartain[2], M. Netherland[3]; [1]U.S. Army Engineer Research and Development Center, Baton Rouge, LA, [2]U.S. Army Engineer Research and Development Center, Vicksburg, MS, [3]University of Florida, Gainesville, FL (225)

ABSTRACT

The synthetic auxin herbicide florpyrauxifen-benzyl was recently registered in the U.S. to control submersed, floating, and emergent aquatic vegetation. Due to limited concentration exposure time (CET) data, small-scale trials were conducted under various CET scenarios to investigate efficacy against dioecious hydrilla (*Hydrilla verticillata* L.f. Royle) and hybrid watermilfoil (*Myriophyllum spicatum x M. sibiricum*) as well as selectivity against the non-target species water stargrass (*Heteranthera dubia* (Jacq.) MacMill) and elodea (*Elodea canadensis* Michx.). Hydrilla exposed to florpyrauxifen-benzyl at 12, 24, or 36 μg a.i. L^{-1} for 12, 24, or 48 hr during the summer (August) was reduced by 30 to 75% 8 weeks after treatment (WAT). A follow up trial in the spring (May) evaluated florpyrauxifen-benzyl against immature (recently established) and mature (overwintered) hydrilla. The results indicated no differences in efficacy between the two plant growth stages and 33 to 85% control was achieved. In a growth chamber trial, hybrid watermilfoil dry weight biomass was reduced 98 to 100% when florpyrauxifen-benzyl was applied at 3 to 12 μg a.i. L^{-1} at 3 to 24 hr exposure times 4 WAT. In a follow up trial, plant control ranged from 50 to 100% with 3 to 9 μg a.i. L^{-1} at 0.5 to 4 hr exposure periods. In particular, florpyrauxifen-benzyl at 6 and 9 μg a.i. L^{-1}, regardless of exposure period, provided ≥95% control. In addition, water stargrass and elodea demonstrated relative tolerance to the herbicide at concentrations up to 6 μg a.i. L^{-1} for 4 hr and 9 μg a.i. L^{-1} for 1 hr. These data provide evidence that florpyrauxifen-benzyl possess utility for selectively managing difficult to control invasive species.

FIELD DEMONSTRATIONS OF SELECTIVE CONTROL OF MAJOR US AQUATIC INVASIVE PLANTS USING PROCELLACOR (A.I., FLORPYRAUXIFEN-BENZYL). M. A. Heilman*[1], K. D. Getsinger[2], D. Jones[3], J. Ferrell[4]; [1]SePRO, Carmel, IN, [2]U.S. Army Engineer Research and Development Center, Vicksburg, MS, [3]University of Florida, Lake Alfred, FL, [4]University of Florida, Gainesville, FL (226)

ABSTRACT

ProcellaCOR™ Aquatic Herbicide (a.i. florpyrauxifen-benzyl) received its USEPA registration in February 2018. It is the first new herbicide approved by USEPA with an aquatic use as part of its initial registration since 1986 (Sonar®). The EPA Reduced Risk technology has novel, low-rate (100X lower than older technology), selective, systemic activity on major US aquatic invasive weeds including hydrilla, Eurasian and hybrid Eurasian watermilfoil, floating hearts, parrotfeather, and water hyacinth. This presentation will highlight results of quantitative vegetation assessments and dissipation monitoring for two summer 2018 demonstration treatments documenting selective, systemic control with ProcellaCOR: spot Eurasian watermilfoil treatment on 1.4 ha on the Lake Pend Oreille system in northern Idaho and partial application to 20 ha of dioecious hydrilla in a small public lake in central Florida (Fish Lake, Osceola County). These active projects have been collaboratively conducted by private and public research teams to document the selective control outcomes reviewed in this paper.

HERBICIDE TRIALS WITH BRAZILIAN EGERIA (*EGERIA DENSA)* FOR MANAGEMENT IN THE SACRAMENTO / SAN JOAQUIN RIVER DELTA. J. D. Madsen*; USDA-ARS, Woodland, CA (227)

ABSTRACT

EVALUATION OF METSULFURON-METHYL FOR CONTROLLING GIANT SALVINIA. W. J. Prevost*[1], C. R. Mudge[2]; [1]Louisiana State University, Baton Rouge, LA, [2]U.S. Army Engineer Research and Development Center, Baton Rouge, LA (228)

ABSTRACT

The invasive aquatic fern, giant salvinia (*Salvinia molesta*) has become a major problem throughout the southeastern U.S. during the past twenty years. Most infestations in Louisiana are managed chemically with a combination of the aquatic herbicides glyphosate and diquat. Due to the difficulty of chemically controlling giant salvinia, the limited number of efficacious herbicides, and the need to rotate herbicides to prevent the development of herbicide resistance, there is a need to find additional herbicides for the management of giant salvinia. Recent research evaluated several non-aquatic herbicides and found metsulfuron-methyl provided 98 to 100% control at 21 to 84 g a.i. ha^{-1}. However, additional research is needed to further investigate the activity of this herbicide at additional application rates and in combination with other herbicides. Therefore, a mesocosm trial was conducted at the LSU AgCenter Aquaculture Research Facility in Baton Rouge, Louisiana, to determine the efficacy of foliar applied metsulfuron on giant salvinia at 2.6, 5.3, 10.5, 21.1, 42.1, 84.1, and 168.2 g a.i. ha^{-1}. Metsulfuron reduced plant dry weight 94 to 100% at 5.3 to 168.2 g a.i. ha^{-1} at 8 WAT. Also, the calculated LD_{90}, or lethal dose to kill 90% of the test population, was 3.8 g a.i. ha^{-1}. An additional mesocosm trial was conducted to evaluate the efficacy of metsulfuron alone and in combination with glyphosate, carfentrazone-ethyl, diquat, or flumioxazin in comparison to glyphosate + diquat and glyphosate + flumioxazin. Metsulfuron was compatible with all herbicide tank mix partners and provided ≥98% giant salvinia control regardless of treatment. Based on this data, metsulfuron alone or in combination with previously registered aquatic herbicides is highly efficacious against giant salvinia when applied to the foliage.

DOES GIANT SALVINIA IMPACT AERIAL COLONIZATION OF AQUATIC INSECTS? C. Wahl*; Louisiana State University AgCenter, BATON ROUGE, LA (229)

ABSTRACT

Mats of giant salvinia (*Salvinia molesta* Mitchell) alter environmental conditions, such as light availability and habitat structure, which shape ecosystem function. However, studies examining implications of giant salvinia on aquatic organisms are limited. Life history of aquatic insects involves a larval or nymph phase, which lives under the water, and the adult phase where the insect emerges from the water. During the adult phase aquatic insects leave the water to reproduce then lay eggs under the water surface, thus initiating the life cycle over again. The presence of giant salvinia during the emergence and egg laying phase could hinder the ability of aquatic insects to successfully complete their life cycle and properly start the next generation. To examine the impact of giant salvinia on aquatic insect aerial colonization, a mesocosm study with varying giant salvinia coverage was conducted. The objectives of the research were to 1) determine if aerial colonization is impacted by giant salvinia presence, and 2) determine at what level of giant salvinia coverage is aerial colonization hindered. To understand how giant salvinia impacts aerial colonization plants were established at 0, 25, 50 or 100% and plants were maintained at these level for the remainder of the trial. Environmental parameters within each mesocosm were sampled every two weeks, while aquatic insect community was sampled monthly. Preliminary results exhibited a reduction in aquatic insect abundance and richness when giant salvinia coverage is 100%, while other coverage treatments displayed limited impacts on aquatic insect communities. Further analysis will examine how specific insect orders, families and feeding strategies are impacted. Also, abiotic conditions including, light viability, dissolved oxygen and pH were altered due to the presence of giant salvinia. This study demonstrates that the presence of a giant salvinia has negative implications for aquatic insect abundance and richness, which may have consequences for the function of the aquatic ecosystem.

CHALLENGES AND OPPORTUNITIES FOR BIOLOGICAL CONTROL OF NON-NATIVE WEEDS IN LOUISIANA. R. R. Diaz*[1], V. Manrique[2], M. B. Rayamajhi[3], C. Wahl[4], R. Watson[1]; [1]Louisiana State University, Baton Rouge, LA, [2]Southern University and A&M College, Baton Rouge, Baton Rouge, LA, [3]USDA, Cooper City, FL, [4]Louisiana State University AgCenter, BATON ROUGE, LA (230)

ABSTRACT

IS BIOLOGICAL CONTROL METHOD A VIABLE OPTION FOR INVASIVE WEED MANAGEMENT? RECENT EXAMPLES FROM FLORIDA. M. B. Rayamajhi*; USDA, Cooper City, FL (231)

ABSTRACT

The ultimate goal of the invasive plant biocontrol programs is to suppress the populations of invasive plants and turn them into the components of the plant diversity in an affected ecosystem. Weed suppression via biocontrol approach should reverse environmental degradation through a slow but steady landscape-wide rehabilitation process without causing collateral damage to the biotic and abiotic environment of a target ecosystem. Herein, we summarize two recent examples: *Melaleuca quinquenervia* (melaleuca) and *Dioscorea bulbifera* (air potato) biocontrol in Florida that elucidate some benefits to the environmentally degraded ecosystems. Melaleuca, a tree species of Australian origin introduced in Florida during early 1900s became one of the most invasive plants in ecologically sensitive wetlands of southern Florida. In 1997, we implemented melaleuca biocontrol project and established replicated permanent plots in melaleuca infested sites that were previously inoculated with biological control agents: weevil, *Oxyops vitiosa* Pascoe; psyllid, *Boreioglycaspis melaleucae*, Moore; leaf-gall fly, *Lophodiplosis trifida* Gagne; and an adventive rust-fungus *Austropuccinia psidii* (G. Wint.) Beenken and evaluated their impact on melaleuca stand dynamics for ca 16 years. Population density of the monitored biocontrol weevil fluctuated during the study years reflecting the carrying capacity of the melaleuca foliage in the canopy; density of other agents could not be documented. Biocontrol damage of foliage increased from 4% in 1999 to 80% during 2006 through 2011. Seed rain patterns during the same period revealed three general configurations: 'normal' (first 5-years), 'spiked' (next 4-years) and significantly reduced (last 5-years) amount; this overall pattern matched the melaleuca leaf litter damage by biocontrol agents. The initial 12.8% viability and 10.8% germinability of melaleuca seeds from 1997-98 decreased to 8.4% and 7.0%, respectively, by 2009-2010. During study period, mean stem density of melaleuca decreased from >60K to <4K ha-1. Reduced quantity and quality of rained melaleuca seeds is expected to suppress melaleuca seedling recruitment and further melaleuca invasion in new areas. Similarly, air potato plant (*Dioscorea bulbifera* L.) is a perennial weedy vine of Afro-Asian origin, introduced into Florida, USA during 1905. It has spread and established throughout Florida, and parts of southern Georgia, Alabama, Louisiana and Texas where it has invaded various upland ecosystems and smothered associated vegetation in private as well as public properties. A biological control program has been implemented in Florida beginning 2011 by releasing an air potato specific biological control agent, beetle *Lilioceris cheni* Gressit and Kimoto, imported during 2002 from its native habitats in Nepal and China after vigorous tests for its specificity towards air potato vine. In order to evaluate beetles biocontrol impact at the landscape level we established five research sites, each with three control and three insect plots (5.0 m x 3.0 m) in four counties of Florida during 2012. Control plots were protected by quarterly application of insecticide Aloft ai Clothianidin 0.250% and Bifenthrin 0.125% by weight at the rate of 3.5 gm/m2) while insect plots were inoculated with beetles. These plots were monitored for beetle feeding-damage and its impact on the performance (vine damage and subsequent impact bulbil production) of air potato plants and the recovery of native vegetation during 2012–2016. The outcome of this 5-year study revealed: 1) a significant reduction (73%) in smothering effect of air potato vines on native vegetation and two-fold increase in plant species richness; 2) a decrease in % of vine cover increased vine damage with the progression of the growing and 3) a significant reduction in bulbil biomass/size (about 85%) and densities (about 98%). So far, the leaf feeding beetles have proven to be efficacious and environment friendly alternate option for air potato management program in Florida and is expected to have comparable results in other states as well. These two recent examples along with many other examples related to various weed systems have shown that the biological control agents, discovered and proven to be host specific, can be safely and successfully used to suppress the negative impacts of exotic invasive plants.

EVALUATION OF IMPROVED HERBICIDAL TECHNIQUES FOR CRESTED FLOATING HEART *(NYMPHOIDES CRISTATA)* MANAGEMENT. R. Richardson*; North Carolina State University, Raleigh, NC (232)

ABSTRACT

Crested floating heart (*Nymphoides cristata*) is a floating-leaf aquatic plant species native to Asia (Burks 2002), but was recently introduced to the southeastern United States where its population is rapidly expanding (Willey 2012). Previously studied biological and mechanical control practices have been unsuccessful in controlling *N. cristata*, so effective chemical treatments are important for the future of *N. cristata*management in the United States (Wiley and Langeland 2011). A concentration exposure time experimental trial (CET) was conducted on *N. cristata*using florpyrauxifen-benzyl, dipotassium salt of endothall, mono(N,N-dimethylalkylamine) salt of endothall and a combination of dipotassium salt of endothall and mono(N,N-dimethylalkylamine) salt of endothall. Based on morphological assessments 4 weeks after treatment, it was determined that all dipotassium salt of endothall treatments with 72 hour or static exposure provided 73% or greater control on *N. cristata*. Additionally, all florpyrauxifen-benzyl treatments with 72 hour or static exposure provided 89% or greater control on *N. cristata*. Results from this trial informed a field trial on *N. cristata* at Lake Moultrie, SC in 2018. Results will be discussed.

MANAGEMENT OF PROBLEMATIC NATIVE AQUATIC VEGETATION TO ENHANCE MULTI-USER BENEFITS IN SOUTHEASTERN WATERBODIES. K. L. Calhoun*, G. N. Ervin, L. G. Turnage; Mississippi State University, Starkville, MS (233)

ABSTRACT

Nuisance aquatic plant species can negatively affect recreation as well as biological processes. They can restrict access to water bodies by boaters, displace desirable plant species, reduce overall biological diversity, reduce utility of aquatic habitat to wildlife, and change ecosystem services (e.g., water quality). Four such species presently are posing management problems for the Sam D. Hamilton Noxubee National Wildlife Refuge, in east-central Mississippi. American lotus (*Nelumbo lutea*), white waterlily (*Nymphaea odorata*), water shield (*Brasenia schreberi*), and American frogsbit (*Limnobium spongia*) are problematic native species at the refuge, and across the region. Unfortunately, few methods are currently known that allow for the effective control of native nuisance species such as these, while also minimizing negative impacts to desirable species, to water quality, and to the aquatic habitat. Our work is aimed at determining optimally effective methods of managing problematic aquatic plants while also minimizing those negative impacts. We are exploring a variety of herbicides (2,4-D, glyphosate, triclopyr, flumioxazin, imazamox, imazapyr, florpyrauxifen-benzyl) and their effects on plant attributes and water quality attributes. We set up mesocosm trials to evaluate the six systemic herbicides and one contact herbicide (at a low and high dose each) for ability to control the four target species. The plant attributes measured were: percent mortality, percent cover, leaf and inflorescence number, and dry biomass. The water quality attributes measured were: temperature, dissolved oxygen, conductivity, pH, nitrate and ammonium. Within the first three weeks after treatment, we observed rapid response to some of the herbicides, and all modes of action reduced abundance of all the target species, while having low impact on water quality. Treatments showing the highest levels of persistent control after six months will be field tested on lakes at the Sam D. Hamilton Noxubee National Wildlife Refuge during 2019.

CAN SEAWATER BE USED FOR SELECTIVE MANAGEMENT OF BRAZILIAN PEPPERTREE IN MANGROVE COMMUNITIES? S. F. Enloe*, C. C. Jacono; University of Florida, Gainesville, FL (234)

ABSTRACT

Brazilian peppertree is an aggressive shrub that has invaded over 280,000 hectares in Florida. Although commonly viewed as a problem of upland and non-saline wetlands, peppertree has invaded thousands of hectares of mangrove communities in south Florida and has become a significant threat to many coastal areas. While the salt tolerance of mangroves is well understood, less is known regarding Brazilian peppertree and salinity. However, observations from infested coastal dunes indicate significant salt pruning of peppertree. This suggests that seawater could possibly be used to selectively suppress peppertree in mangrove communities. This would be very useful, given a lack of other selective control measures when mangroves are present. This idea has already been validated for herbaceous weed control in salt-tolerant turf. Therefore, our objective was to evaluate foliar applications of seawater mixed with different adjuvants for Brazilian peppertree control. Two greenhouse studies were conducted in 2017 and 2018 at the UF Center for Aquatic and Invasive Plants in Gainesville, FL. Juvenile saplings of Brazilian peppertree, red, black, white, and buttonwood mangroves were established in 2.4 to 12 liter pots and grown at a salinity of 7 parts per thousand. Following establishment, a commercial salt formulation was used to create artificial seawater with a salinity of 35 parts per thousand. In study one, a methylated seed oil (1%v/v) and a non-ionic surfactant (0.25% v/v) were tested with either deionized water or artificial seawater on all five species. In study two, a d-limonene based adjuvant was tested at three rates (2.3, 4.6, and 9.3 l/ha) and two application volumes (187 and 1,870 l/ha) with artificial seawater on Brazilian peppertree alone. For both studies, post treatment measurements of plant stress were taken with a portable chlorophyll meter at multiple times between two and twelve weeks after treatment. In study one, analysis of variance indicated there were no significant differences in water source or adjuvant for any of the five species tested. Visual observations agreed with chlorophyll readings as no noticeable impacts on the foliage were observed. In study two, Brazilian peppertree chlorophyll content was not impacted by d-limonene rate. However, the higher application volume reduced chlorophyll content by approximately 15%. This was barely discernable with visual observations and no defoliation occurred with any treatment. These studies indicate Brazilian peppertree exhibits considerable tolerance to foliar applications of seawater with multiple adjuvant types and that this is not likely to be an effective control method in sensitive mangrove communities.

DEVELOPMENT OF AN AUTONOMOUS APPLICATION SYSTEM FOR AQUATIC PLANT MANAGEMENT. R. Richardson*[1], S. Hoyle[1], J. Nawrocki[2]; [1]North Carolina State University, Raleigh, NC, [2]UPI, Inc., Raleigh, NC (235)

ABSTRACT

Aquatic vegetation surveys and aquatic herbicide applications are integral components of vegetation management programs that protect water resources. However, surveys and herbicide applications can be labor intensive and provide opportunities for introducing cost saving measures. The goal of this project was to design, prototype, and demonstrate a small fleet of autonomous aquatic vehicles (AAVs) capable of detecting, quantifying, and selectively applying herbicide to manage invasive aquatic weed infestations. To date, three AAVs have been developed to evaluate performance, durability, and operational capacity. Field testing of these units has been conducted. Utilization of a trolling motor provided approximately 9x increased thrust over an air propeller and also improved turning radius. Incorporation of a lithium iron phosphate battery significantly reduced weight and increased carrying capacity while also allowing for rapid charging. Autonomous tracking of two AAVs concurrently has been implemented and demonstrated. Successful collection of hydroacoustic data as well as herbicide application through the AAVs has also been verified. Further research is being conducted to optimize the current systems prior to commercialization.

BIO-ECONOMIC MODELS PRIORITIZING EAST MAUI WATERSHED PROTECTION AGAINST MICONIA INVASION. J. J. Leary*[1], N. A. Jorgensen[2], M. Renz[3], K. Burnett[4], C. Wada[4], B. V. Mahnken[5]; [1]University of Florida- Institute of Food and Agricultural Sciences, Gainesville, FL, [2]University of Wisconsin-Madison, Madison, WI, [3]University of Wisconsin, Madison, WI, [4]University of Hawaii-Manoa, Honolulu, HI, [5]University of Hawaii-Manoa, Makawao, HI (236)

ABSTRACT

Miconia (*Miconia calvescens* DC) is a highly fecund, autogamous species, with propagules dispersed by avian zoochory. It's considered to be one of the worst plant invaders in Hawaii and the Pacific Basin. Miconia was introduced to the East Maui Watershed (EMW) almost a half-century ago with over a quarter-century of management recorded. Using a historical spatio-temporal dataset of eliminated targets, we constructed probability distribution kernels estimating invasion dispersal and persistence; progeny dispersed out to 1636m and propagule bank extinction was beyond 20 years, respectively. This allowed us to project optimal eradication of a local, incipient population with an annual harvest rate eliminating all juveniles before reaching maturity, until extinction. Corresponding (optimal) management efforts were monetized based on current pricing for helicopter operations; the variable cost to locally eradicate an incipient population from a single maternal source was estimated to be <$42K USD, with ~90% of the effort searching for the most distant 1% of the progeny and expended within the first 9 years after the mature discovery. We also estimated that it was more economical to apply excess effort towards eradication, rather than under-invest efforts to be biologically outpaced by the invader, resulting in catastrophic failure. We further report on the development of a habitat suitability model of miconia colonzing the EMW with an ensemble of five algorithms associating presence data with four variables of the physical environment (e.g., precipitation, temperature, aspect and slope). Early interpretation of the model shows a segregation of suitable habitats for immature and mature plants further elucidating the potential impact of a colonizer based on another important life history trait (i.e., fecundity). The invasion kernels and suitable habitat model create synonymous probability surfaces that can multiply the likelihood of impact and further translate a cost-benefit metric to optimize the distribution of resources with the maximum reduction of impact.

A LOW COST INDIVIDUAL PLANT APPLICATOR. J. D. Byrd, Jr.*; Mississippi State University, Mississippi State, MS (237)

ABSTRACT

Although time consuming, individual plant treatments (IPT) can be a highly effective method to selectively control individual woody species with minimal negative impact to off-target species. Potential negative aspects of equipment used for these type applications include accurate measurement of herbicide dosage into the incision, long-term functionality of the equipment, and costs of application devices. One potential solution to alleviate these issues is to attach a line-fill livestock vaccine repeat dose syringe to a hydration backpack with a 6.4 mm (¼ inch) or 10 mm (3/8 inch) barbed line connector. Since many herbicide labels for IPT hack and squirt applications recommend ½ to 1 ml of herbicide concentrate or diluted (1:1 to 1:3) with water, the 1 ml adjustable line-fill vaccinator, such as the Neogen Ideal Prima is the ideal device to deliver herbicide into the incision. These vaccinators can be ordered from a wide range of online livestock supply or local retailers at a cost of around $25. The hydration backpack is a convenient and inexpensive device to carry up to 2 L of herbicide and are widely available at retailers in the camping supply or sporting goods section. Hydration backpack costs are more variable and range from $15 to $100, making this applicator readily available, accurate dosage delivery and convenient to carry and use. Hydration backpacks used for this purpose should be clearly marked to avoid accidental use for water consumption.

COMPARISON OF HERBICIDE OPTIONS FOR GUARDRAILS AND CABLE BARRIERS. J. Omielan*; University of Kentucky, Lexington, KY (238)

ABSTRACT

For highway safety guardrails and cable barriers need to be kept clear of visual obstructions. Usually that means maintaining a vegetation free zone underneath them. Applications of broad spectrum residual herbicides have become the mainstay for bareground maintenance operations in combination with a broad spectrum post-emergent herbicide like glyphosate. A number of newer products have been introduced to this market. Our group has been evaluating the efficacy of newer and older products and combinations for a number of years. There are a number of treatments that were the same in the 2012, 2013, 2017, and 2018 trials. How consistent was their performance?

The 2012/2013 trials were established under and beside guardrail near Paintsville, KY in 2012 and near Elizabethtown in 2013. In both years, 13 treatments and 3 replications were arranged in a randomized complete block design. Treatments were applied at 25 gallons/acre onto 6.5 ft by 12 ft plots on April 25, 2012 and May 23, 2013. The 2017/2018 trials were established under and beside cable barrier with a mixed species turf underneath in the median of I-265 in Louisville, KY. The 16 treatments and 3 replications were arranged in a randomized complete block design. Treatments were applied at 25 gallons per acre onto 6.5 ft wide by 20 ft long plots on June 21, 2017 and May 23, 2018.

All treatments included Roundup ProMax or Rodeo (glyphosate) for post-emergence control. Treatments with older, high use rate herbicides included Sahara (diuron + imazapyr), Hyvar (bromacil), Pendulum (pendimethalin), and Endurance or Proclipse (prodiamine). Other herbicides used were Oust XP (sulfometuron), Oust Extra (sulfometuron + metsulfuron), Payload (flumioxazin), Cleantraxx (penoxsulam + oxyfluorfen), Arsenal or Polaris AC Complete (imazapyr), Plateau (imazapic), and Journey (glyphosate + imazapic). Newer low use rate products tested included Milestone (aminopyralid), Method (aminocyclopyrachlor), Perspective (aminocyclopyrachlor + chlorsulfuron), Streamline (aminocyclopyrachlor + metsulfuron), Viewpoint (aminocyclopyrachlor + metsulfuron + imazapyr), and Esplanade (indaziflam).

Visual % bareground ratings were taken 40 (6/4), 85 (7/19), and 160 (10/2) days after treatment (DAT) in 2012 and 56 (7/18), 98 (8/29), and 138 (10/8) DAT in 2013. Ratings were taken 21 (7/12), 48 (8/8), 98 (9/27), 127 (10/26), 309 (4/26/18) DAT in 2017 and 41 (7/3), 72 (8/3), 119 (9/19), and 153 (10/23) DAT in 2018. Data were analyzed using ARM software and treatment means were compared using Fisher's LSD at $p = 0.05$.

There were eight treatments in common across the four trials. In 2013 and 2017 all these treatments had more bareground than control throughout the season. In 2012 Roundup by itself was the same as control after the first assessment. In 2018 a number of treatments were the same as control after the first assessment. The most consistent treatment across the years was Esplanade + Oust XP. The most effective treatments included older, high use rate herbicides as well as low use rate herbicides by themselves. They were also effective as combinations with other low use rate herbicides or as combinations with high use rate ones. The introduction of new products has increased the available control options.

ARE NON-SYNTHETIC HERBICIDES USEFUL FOR WEED CONTROL IN RICE? S. Abugho*[1], A. V. Pagenotto[2], X. Zhou[3], M. V. Bagavathiannan[1]; [1]Texas A&M University, College Station, TX, [2]University of Sao Paulo, Sao Paulo, Brazil, [3]Texas A&M University, Beaumont, TX (239)

ABSTRACT

Organic rice production has steadily increased in Texas, despite the challenges associated with weed control in this system. Non-synthetic herbicides, some are plant extract based, may be useful for weed control in organic rice; however, limited information is available on the efficacy of non-synthetic herbicides on dominant weeds present in Texas rice. A greenhouse experiment was conducted at Texas A&M University, College Station, TX during summer to fall 2018 to evaluate the spectrum of activity of seven non-synthetic herbicides (20% vinegar, 30% vinegar, Alldown, BurnOut, WeedZap, Avenger, and Suppress) on important weed species in rice, including barnyardgrass (*Echinochloa crus-galli*), broadleaf signalgrass (*Urochloa platyphylla*), large crabgrass (*Digitaria sanguinalis*), hemp sesbania (*Sesbania herbacea*), tall morningglory (*Ipomoea purpurea*) and yellow nutsedge (*Cyperus esculentus*). The experimental design was a randomized complete block with four replications. Five seeds (or tubers) each of the study species were planted in plastic pots (20 cm length x 8 cm width) filled with potting soil mix. A nontreated check was included for visual comparison. Label recommended rates of non-synthetic herbicides were applied and evaluated for weed control at three weed growth stages: 3, 6, and 15 cm tall. Weed control was visually estimated on a scale of 0 to 100 (0%=no injury; 100%=plant death) at 3, 7, 14, and 21 days after application (DAA). After the final observation at 21 DAA, aboveground biomass was harvested and weighed after drying in an oven for 72 hrs. Suppress (31 ml L^{-1} Volume/Volume [V/V]) caused the most injury (47% injury) to broadleaf signalgrass at 3 DAA. BurnOut (332 ml L^{-1} Volume/Volume [V/V]) was injurious to hemp sesbania (32%) and tall morningglory (82%) at 3 DAA. Very minimal injury and no biomass reduction was observed in yellow nutsedge regardless of the treatment applied. Though none of the non-synthetic herbicides provided excellent control of any of the weed species tested, some are still useful as part of an integrated weed management program in organic rice, which needs to be investigated further.

EFFICACY OF TRIFLUDIMOXAZIN ALONE AND IN COMBINATION WITH GLUFOSINATE, GLYPHOSATE, PARAQUAT, AND SAFLUFENACIL ON EMERGED TALL WATERHEMP (*AMARANTHUS TUBERCULATUS*). N. R. Steppig*[1], S. Willingham[2], D. M. Whalen[3], B. G. Young[4]; [1]Purdue University, Lafayette, IN, [2]BASF, Seymour, IL, [3]University of Missouri, Columbia, MO, [4]Purdue University, Brookston, IN (240)

ABSTRACT

Co-application of two or more herbicides, commonly referred to as tank-mixing, is a widely-used practice in agricultural systems. Tank-mixtures can improve overall weed control spectrum compared to individual herbicides applied alone; and the use of multiple herbicide modes of action in a single application can delay the onset of herbicide resistance in weed populations. In order to examine potential interactions with trifludimoxazin, a new PPO-inhibiting herbicide under development by BASF, with other herbicides when applied to tall waterhemp, field trials were conducted in 2017 and 2018 near Brookston, Indiana. Experiments included trifludimoxazin at three different rates (0, 12.5, and 25 g ai ha-1) applied alone, and in combination with glufosinate (593 g ae ha-1), glyphosate (870 g ae ha-1), paraquat (840 g ai ha-1), or saflufenacil (25 g ai ha-1). Herbicide applications were made when tall waterhemp in the trial area ranged from 15 to 20cm in height. Additionally, four plants within each plot measuring 18cm in height were marked prior to application. Applications of 12.5 and 25 g ai ha-1 of trifludimoxazin alone resulted in 97 and 98% tall waterhemp control, respectively, at 14 DAA in the 18cm plants. Trifludimoxazin applied at 12.5 g ai ha-1 plus glufosinate, glyphosate, saflufenacil, or paraquat, resulted in control of 97, 98, 99, and 99% control of the marked plants at 14 DAA, respectively. Trifludimoxazin applied at 25 g ai ha-1 in plus glufosinate, glyphosate, saflufenacil, or paraquat resulted in ≥99% control in all combinations. Biomass from the marked plants were collected at 28DAA, and data were analyzed via Colby's method. Interestingly, although visual control ratings exceeded 97% for all combinations, trifludimoxazin mixed with either glufosinate or glyphosate was deemed antagonistic following analysis via Colby's method. However, this should be considered a false antagonism since near complete control was observed for the herbicides applied alone, which left little opportunity to achieve an additive or greater response for the combination. Aside from these mixtures, all other combinations had an additive effect; however, more research in a greenhouse setting using additional herbicide rates will be conducted in the future to further investigate interactions with trifludimoxazin with these herbicides.

INTEGRATED WEED MANAGEMENT SYSTEMS TO CONTROL COMMON RAGWEED IN VIRGINIA SOYBEAN. S. C. Beam*[1], M. L. Flessner[2]; [1]Virginia Tech, Concord, NC, [2]Virginia Tech, Blacksburg, VA (241)

ABSTRACT

Herbicide resistance in weeds is driving a push toward integrated weed management. Such approaches use multiple tactics within the growing season reduce selection pressure of any one control tactic on weeds. Studies were initiated across Virginia in 2017 and 2018 to assess an integrated approach to common ragweed (*Ambrosia artemisiifolia* L.) management in soybean. The studies were set up as a 2 by 3 factorial with 5 replications at each location, and 3 locations total. Factor A was soybean planting date (full season or double crop), factor B was cover crop (cereal rye/winter wheat or no cover), and factor C was +/- harvest weed seed control (field residue and weed seed removal or conventional harvest with weed seed returned) at the end of the first growing season. Cereal rye was planted as the cover crop in the full season soybean plots and winter wheat in the double crop plots. Both cereal rye and winter wheat were drilled at 134 kg ha^{-1} in the fall of the year prior to cash crop planting. In the full season cover crop plots the cereal rye was rolled prior to burndown applications being made. Nonselective, nonresidual herbicides were applied to be weed free at planting. Flumioxazin was applied at 89.3 g ai ha^{-1} prior to both soybean plantings. Soybean was planted in the full season plots at 407,550 seed ha^{-1} and drilled in the double crop plots at 494,000 seed ha^{-1}. A POST application of glyphosate + fomesafen was applied at 1107 g ae + 298 g ai ha^{-1}, to all plots of a particular planting date when common ragweed was 30 cm tall in the no cover plots. Data collected included initial common ragweed density via bi-weekly counts for 6 wk from two 0.25 m^2 quadrats per plot. Visible control of common ragweed was also assessed and compared to the nontreated portions of the field margins of the study. End-of-season common ragweed density was assessed from two 0.25 m^2 quadrats per plot and 4 random plants per plot were harvested for above ground biomass prior to soybean harvest. All data were subjected to ANOVA and means separation using Fisher's Protected LSD (α=0.05). Ragweed density varied by location but the lowest densities of common ragweed followed a wheat crop and were 5 to 7.6 plants m^{-2} 6 WAP (prior to POST applications). Other treatments had densities ranging from 3.2 to 26 plants m^{-2}. At harvest, this trend generally continued with densities following a wheat crop of 0.45 to 3.4 plants m^{-2} compared to all other treatments which had densities of 1.5 to 22.5 plants m^{-2}. Visible common ragweed control data followed this same trend with the plots following wheat having the best common ragweed control, 77 to 90% control 6 WAP compared to 13 to 80% for all other treatments. Common ragweed biomass per plant was significantly greater at 2 of the 3 sites in the full season no cover plots ranging from 40.8 to 44.5 g $plant^{-1}$. The other treatments at these 2 sites had biomass ranging from 12.6 to 43.5 g $plant^{-1}$. From this research double cropping soybean behind wheat provides the greatest in-season reductions to common ragweed populations. These reductions can help reduce soil seedbank additions and yield loss reductions. This is an ongoing study and the effect of HWSC practices will be evaluated in the second year.

COTTON (*GOSSYPIUM HIRSUTUM*) DEFOLIATION AS AFFECTED BY DROPLET SIZE AND CARRIER VOLUME. J. P. McNeal*[1], D. Dodds[2], G. Kruger[3], S. Davis[4], L. X. Franca[2], B. Norris[4], J. J. Williams[4]; [1]Mississippi State University, Mississippi State, Mississippi, MS, [2]Mississippi State University, Mississippi State, MS, [3]University of Nebraska-Lincoln, North Platte, NE, [4]Mississippi State University, Starkville, MS (242)

ABSTRACT

A field experiment was conducted to evaluate the effect of carrier volume and spray droplet size on the efficacy of cotton (*Gossypium hirsutum*) harvest aid applications. This experiment was conducted at the R.R. Foil Plant Science and Research Center in Starkville, Mississippi and at the Black Belt Branch and Experiment Station in Brooksville, Mississippi. Four row plots were planted to DP 1646 B2XF. Plot dimensions were 3.9m x 24.4m (Starkville, MS) and 3.9m x 12.2m (Brooksville, MS). Harvest aid applications were made at 60% open boll on 17 September 2018 and 19 September 2018 in Starkville and Brooksville, respectively.

Applications were made with a Capstan® Pinpoint Pulse-Width Modulation (PWM) sprayer on a high-clearance Bowman Mudmaster at a ground speed of 14.5 km $hour^{-1}$. This experiment utilized two carrier volumes: 47 and 187 L ha^{-1}, three droplet sizes: 200 μm, 500 μm, and 800 μm, and three harvest aid materials: thidiazuron (TakeDown® SC) applied at 0.15 kg ha^{-1}, ethephon (BollBuster ®) applied at 1.5 kg ha^{-1}, and tribufos (Folex® 6EC) applied at 0.37 kg ha^{-1}. Harvest aid applications included: [1] thidiazuron + ethephon and [2] thidiazuron + ethephon + tribufos.

Visual ratings were taken at 3, 7, and 10 days after application (DAA) and included percent open bolls, percent green leaves, percent defoliation, percent desiccation, terminal regrowth and basal regrowth. Seed cotton yield data were also collected. Ratings were taken as a percent (%) relative to the untreated control. Seed cotton for each plot was sent to the University of Tennessee in Jackson, TN for ginning, and fiber quality was determined by the USA classing office in Memphis, TN.

The experimental design was a factorial arrangement of treatments within a randomized complete block design with a single untreated check within each replication. Data were analyzed in PROC MIXED in SAS v. 9.4. Means were separated using Fisher's Protected LSD at an alpha level of 0.05.

Pooled over location at 10 DAA, a carrier volume of 187 L ha^{-1}, a droplet size of 800μm, and a tank-mix of thidiazuron + ethephon reduced green leaves by only 55% ($p = 0.0104$) and increased defoliation by only 51% ($p = 0.0256$). Desiccation varied due to carrier volume x tank-mix ($p = 0.0356$) and droplet size x tank-mix ($p = 0.0035$). However, desiccation levels were all ≤ 3%, and are therefore largely inconsequential. A carrier volume of 187 L ha^{-1}, a droplet size of 200μm, and a tank-mix of thidiazuron + ethephon + tribufos resulted in the most regrowth observed of 12% ($p = 0.0201$).

Consequently, an application volume of 47 L ha^{-1} and a droplet size of 500μm and a tank-mix of thidiazuron + ethephon with or without tribufos reduced green leaves by ≥ 85% (0.0104).

Carrier volume, droplet size, and harvest aid program had no effect on percent open bolls, leaf grade, or fiber quality. Our results indicate lower carrier volumes may have utility in cotton harvest aid programs. In such cases, efficacy may vary due to concentration of active ingredient within the spray droplet.

ANTIOXIDANT RESPONSES TO WEED COMPETITION IN ARABIDOPSIS AND MAIZE. N. Berardi*, C. J. Swanton, S. Amirsadeghi; University of Guelph, Guelph, ON (243)

ABSTRACT

Changes in light quality induced by the presence of neighbouring weeds is an important mechanism of plant competition effecting crop plants during the early stages of seedling development. Alteration of the light environment is recognized via changes in the red/far-red light ratio (R/FR), in which a reduction in R/FR is induced by light that is reflected upwards off weeds. Recognition of a reduced R/FR elicits physiological stress responses within the crop plant characterized by increased reactive oxygen species (ROS) production and subsequent modification of antioxidant capacity to regulate ROS levels. The resulting physiological responses due to the presence of neighbouring weeds are hypothesized to be the cause of significant yield losses during early season weed competition. To explore the associated stress and antioxidant responses to weed competition the model species, *Arabidopsis* and maize were studied under two light environments, a high R/FR (weed-free, FR-D) environment, and a low R/FR environment (weedy, FR-E). Results indicate that in response to the low R/FR light environment the proportion of reduced ascorbate, a potent antioxidant, was significantly decreased when compared with the weed-free light environment in both *Arabidopsis* and maize. Fluctuations in associated antioxidant regenerating enzymes were also observed in both species. These results demonstrate the importance of elucidating the molecular basis of weed-crop competition. Further identification of these responses and associated genes would not only provide important insights into the molecular basis of weed-crop competition, but may also provide targets for improving weed stress tolerance in crop plants.

PHYTOCHEMICAL CHARACTERIXZATION AND BIO-HERBICIDDAL POTENTIAL OF *LANTANA CAMARA L.* AGAINST SELECTED WEEDS OF WHEAT CROP. T. Anwar*[1], N. Ilyas[1], R. Qureshi[1], M. Khan Panni[2]; [1]Pir Mehr Ali Shah Arid Agriculture University, Shamsabad, Murree Road, Rawalpindi,, Pakistan, [2]2Bioactive Natural Products and Phytoceuticals Laboratory, Plant and Soil Building, Michigan State University, East Lansing, MI (244)

ABSTRACT

Lantana camara leaves were screened for bioherbicidal activity on selected weeds of wheat crop (*Avena fatua, Euphorbia helioscopia*, *Chenopodium album, Phalaris minor* and *Rumex dentatus*). Combi*Flash* fraction 2 significantly inhibited seed germination of weed species without effecting growth parameters of wheat out of three *L. camara* leaf methanolic fractions. For *Combiflash* fraction 2, maximum germination (96%) was observed in *T. aestivum* while minimum in *P. minor* (31%). Significant suppression in radical length of all test species was observed by *Combiflash* fraction 2. The highest radical length (97%) was shown for *T. aestivum, E. helioscopia* and *R. dentatus* while the minimum (32%) for *A. fatua*. Similarly, highest plumule length (95%) was observed for *P. minor* and *T. aestivum* while *R. dentatus* exhibited the minimum plumule length (31%). The assessment of physiological effects indicated suppression in chlorophyll, peroxidase (POD), superoxide dismutase (SOD) and protein contents of weeds species by fraction 2. Four active compounds (Methyl oleate, Methyl palmitate, Methyl stearate and Methyl linoleate) were purified by gas chromatography-mass spectroscopy and nuclear magnetic resonance from fraction 2. The weedicidal potential of identified compounds is reported for first time.

ECOSYSTEM SERVICES PROVIDED BY COVER CROPS INTERSEEDED IN CORN. A. P. Brooker*[1], K. Renner[2], C. Sprague[2], L. Tiemann[2]; [1]Michigan State University, Haslett, MI, [2]Michigan State University, East Lansing, MI (245)

ABSTRACT

Interseeding cover crops at the V3 and V6 growth stages in corn allows establishment of grasses, clovers, vetches, Brassicaceae, and cover crop mixtures. There are limited options for weed control when interseeding cover crops, and research has shown that overwintering grass cover crops are especially effective in suppressing winter annual weeds; however, results are mixed on the ability of an interseeded cover crop to suppress summer annual weeds. The objectives of this research were to determine if broadcast interseeded cover crops suppressed summer annual weeds in the year of interseeding and determine if winter annual weeds were suppressed in the fall and following spring. Two experiments with four site years each were conducted, one from 2015-2018, and one from 2017-2019 in Michigan. In the first experiment, annual ryegrass, oilseed radish, crimson clover, and a mixture of the three species were broadcast interseeded at the V1 (2015 only), V2, V3, V4, V5, V6, and V7 corn growth stages. Seeding rates were 18, 9, 18, and 12+2+2 kg ha^{-1}, respectively. Glyphosate was applied immediately prior to interseeding the cover crops at each timing. Cover crop and weed densities were measured 30 days after interseeding (DAI); plant densities and biomass were measured just prior to corn harvest and again the following spring. In the second experiment, annual ryegrass, oilseed radish, crimson clover, and a mixture of annual ryegrass and crimson clover were broadcast interseeded at the V3 and V6 corn growth stages. Standard seeding rates were 17, 11, 22, and 5+17 kg ha^{-1}. Each species was also interseeded at 0.5x and 2x of the standard rate. The same methods from the first experiment were used with the exception that summer annual weeds were removed following the 30 DAI measurements. In the first experiment, fall weed biomass was highest in the no cover control plots. Combined over interseeding timings, fall weed biomass suppression at the time of corn grain harvest was not different between cover crop species. Spring biomass of winter annual weeds was highest at 381 kg ha^{-1} where crimson clover was interseeded compared with 138 kg ha^{-1} where annual ryegrass overwintered. Combined over cover crop species, fall weed biomass was higher in the V2 and V3 interseeding timings at 497 and 286 kg ha^{-1}, respectively, compared with the V4-V7 interseeding timings which ranged from 110-217 kg ha^{-1}. However, spring weed biomass did not differ across interseeding timings. In the second experiment, total weed numbers 30DAI was higher in the V3 compared with V6 interseedings in one site year only. Fall weed biomass was also higher in the V3 compared with V6 at one site year. There were no differences in spring weed biomass. Our results suggest that interseeded cover crops do not stop emergence or establishment of summer annual weeds. Overwintering annual ryegrass suppressed winter annual weeds. Interseeding cover crops after the V3 growth stage in corn will improve early-season weed management of summer annual weeds in interseeded systems.

PHYSIOLOGICAL BASIS FOR THE CONTACT ACTIVITY OF GLUFOSINATE. H. K. Takano*[1], R. S. Beffa[2], C. Preston[3], P. Westra[4], F. E. Dayan[4]; [1]Colorado State University, Ft Collins, CO, [2]Bayer Crop Science, Frankfort / Main, Germany, [3]University of Adelaide, Glen Osmond, Australia, [4]Colorado State University, Fort Collins, CO (246)

ABSTRACT

Glufosinate targets glutamine synthetase (GS), a key enzyme for nitrogen metabolism and photorespiration. Unlike other amino acid biosynthesis inhibitors, glufosinate is a fast-acting herbicide with limited translocation. In this study, Palmer amaranth (*Amaranthus palmeri*) was used as a model species to investigate the physiological basis for the contact activity of glufosinate. Glufosinate uptake increased overtime and reached a maximum at 24 h after treatment. A linear increase in uptake was obtained with a dose response of the herbicide, suggesting that glufosinate uptake is primarily driven by passive transport. Glufosinate translocation in a leaf was 43% acropetal but only 4% basipetal, indicating limited phloem mobility. Photosynthetic electron flow and carbon assimilation were completely inhibited, and ammonia accumulated in high levels following GS inhibition by glufosinate. Inhibition of GS triggered a massive light-dependent generation of reactive oxygen species (ROS), consistent with other contact herbicides. The formation of these free radicals led to accumulation of malondialdehyde, a product of lipid peroxidation, supporting the hypothesis of ROS generation as the main cause for rapid phytotoxicity when plants are treated with glufosinate. Based on these facts, we suggest that inhibition of GS restricts both photorespiration and Calvin Cycle, the two major sinks for the energy generated by the light reactions. Under these circumstances, the fate for the excess of energy is then transferred to molecular oxygen, generating ROS, the causal agent of lipid peroxidation and rapid cell death. A more detailed investigation on how inhibition of GS causes ROS accumulation is currently underway.

CEREAL RYE COVER CROP AND HERBICIDE APPLICATION METHOD IMPACTS COTTON STAND, PALMER AMARANTH CONTROL, AND YIELD. L. C. Hand*[1], R. L. Nichols[2], T. M. Webster[3], A. S. Culpepper[4]; [1]University of Georgia, Tifton, GA, [2]Cotton Incorporated, Cay, NC, [3]USDA-ARS, Tifton, GA, [4]University of Georgia, Tifton, GA (247)

ABSTRACT

Palmer amaranth's (*Amaranthus palmeri* S. Watson) ability to rapidly develop herbicide resistance threatens farm sustainability if more integrated systems are not utilized. The addition of cover crops in this system may be a critical tool to extend the life of herbicides by reducing weed seed emergence as well as improving weed control. High biomass cover crops have demonstrated effective Palmer amaranth control when combined with an aggressive herbicide program, but Georgia growers have been hesitant to adopt this practice due to negative impacts on stand establishment. Therefore, there is a need to develop a system in which stand loss is minimized when planted into a high biomass cover crop while still maintaining the positive impacts gained in weed control. Six field studies ranging from 0.35 to 1.6 ha in size were conducted in 2012, 2013, and 2016 to observe the effects of a rolled heavy rye cover crop (4,886-9,600 kg ha^{-1} dry biomass) on cotton stand, weed control, and yield. Treatments were arranged in a RCBD and included: (1) broadcast drilled rye and broadcast herbicide program, (2) rye drilled with a 25 cm rye-free zone in the cotton row and broadcast herbicide program, (3) rye drilled with a 25 cm rye-free zone with PPI and PRE banded herbicides, and (4) no cover crop and broadcast herbicides. Cereal rye was seeded the previous fall at a rate of 100 kg ha^{-1} and rolled at the time of burndown. Broadcast herbicide program included: paraquat (210 g ai ha^{-1}) + flumioxazin (71 g ai ha^{-1}) + COC (2.34 L ha^{-1}) at burndown; diuron (840 g ai ha^{-1}) + fomesafen (280 g ai ha^{-1}) + paraquat (210 g ha^{-1}) + COC (2.34 L ha^{-1}) PRE; glyphosate (1260 g ae ha^{-1}) + acetochlor (1260 g ai ha^{-1}) POST 1; glyphosate (1260 g ha^{-1}) + *S*-metolachlor (1070 g ai ha^{-1}) POST 2; and diuron (1120 g ha^{-1}) + MSMA (1681 g ai ha^{-1}) + COC (2.34 L ha^{-1}) layby directed. The banded system included the same burndown, POST, and layby applications but included a 25 cm in the row banded PPI application of pendimenthalin (1064 g ai ha^{-1}) + fomesafen (210 g ha^{-1}) and a banded PRE application of diuron (560 g ha^{-1}) + fomesafen (175 g ha^{-1}). Cotton was planted in a single pass with a strip-till planter system placing two seeds every 23 cm. At two of six locations when measuring the plot in its entirety, cotton stand was lowest in uniformity and in plants ha^{-1} with the system in which rye was planted broadcast; at these sites the rye-free zone reduced skips and increased populations. At a third location, cover crop systems had a better stand than the no cover crop system as a result of the cover crop's superior ability to preserve moisture. Stand was not influenced by treatments at other locations. Control of pitted morningglory (*Ipomea lacunosa* L.), sicklepod (*Senna obtusifolia* (L.) H.S. Irwin & Barneby), yellow nutsedge (*Cyperus esculentus* L.), and Benghal dayflower (*Commelina benghalensis* L.) was not influenced by treatments at any location. Similarly, Palmer amaranth control did not differ at 3 of 6 locations when densities were less than 108,000 plants ha^{-1}. However, at three locations with higher Palmer amaranth densities (334,830 to 670,130 plants ha^{-1}), 82 to 86% fewer plants were present with the broadcast drilled rye system and where the rye was drilled with a rye-free zone utilizing broadcast herbicides compared to the no cover or banded herbicide systems. Cotton yields were influenced by Palmer amaranth control at the three intensely populated locations with 9 to 16% higher yields from the two most effective Palmer amaranth management systems.

PREDICTION OF PPO-INHIBITOR RESISTANCE RISK THROUGH GENOMIC ANALYSIS. A. L. Barker*, F. E. Dayan; Colorado State University, Fort Collins, CO (248)

ABSTRACT

PPO-inhibiting herbicides were introduced in the 1960s and became important tools for weed control in soybean fields. These herbicides target porphyrin synthesis and their action is associated with the light-dependent catastrophic consequences of disrupting chlorophyll synthesis. Resistance was first reported in 2001 in common waterhemp and has now been reported in ten different species of weeds in six different countries. While most of the chloroplastic porphyrin pathway is directed to chlorophyll synthesis (the most abundant pigment in the world), heme is also present in the chloroplasts because it is necessary for the function of cytochrome P450s, electron transport chains, and even photosynthesis. There are two known target-site mutations leading to resistance occurred on the mitochondrial isoform (PPX2), instead of the chloroplast isoform (PPX1), a single SNP Arg98 to Leu or Gly in giant ragweed and palmer amaranth and a codon deletion of Gly210 in common waterhemp and palmer amaranth. There is evidence that this protein, PPO2, may then be dual targeted to both the chloroplast and the mitochondria. An in-depth sequence analysis was preformed to determine which species were capable of the Gly210 deletion, the Arg98 deletion, and in some cases the possible dual-targeting. These results identify a few troublesome weed species which should be monitored for rapid development of resistance to PPO inhibitors, but since the sequence data is not available for most weedy species we can only make general inferences based on related phyla.

TRADEOFFS BETWEEN PLANTING DATE, COVER CROP BIOMASS, AND WEED SUPPRESSION IN AN ORGANIC NO-TILL SYSTEM USING TARPS. N. P. Lounsbury*, R. G. Smith; University of New Hampshire, Durham, NH (249)

ABSTRACT

Organic rotational no-till (ORNT) relies on growing high-biomass cover crops that are mechanically terminated to provide a weed suppressing mulch. Under the right conditions, biomass can exceed 8 Mg ha^{-1} and eliminates the need for further weed control. In cool climates, however, cover crop production generally falls short of this level. Furthermore, this system is limited to producers who have specialized equipment for cover crop termination, which is not the case for many vegetable growers. To modify the ORNT system for vegetable growers in cooler climates, we have investigated the use of black tarps to terminate cover crops and provide additional weed suppression. This experiment was designed to elucidate the trade-offs between tarp application date and duration on weed and mulch dynamics. A cereal rye (*Secale cereale* L.) and hairy vetch (*Vicia villosa* Roth) cover crop was grown on all plots. Treatments were termination date (June 13, June 23, and July 3) and tarp duration (10, 20, and 30 days). A glyphosate treatment was also included as a control on all termination dates. The twelve treatments resulted in five potential crop planting dates. Termination date had a strong effect on cover crop biomass, which reached 3.4, 4.2, and 5.6 Mg ha^{-1} on the three dates. Termination date and tarp duration both affected

weed abundance. However, tarp duration had a more pronounced effect on weed biomass and weed community composition when cover crop biomass levels were lower (i.e., first two termination dates); at the highest cover crop biomass, there were no differences in weed biomass or weed community composition between any of the termination treatments. Tarps are as effective at terminating cover crops as glyphosate, and could be a useful tool for organic growers, particularly when cool climates or other factors limit cover crop biomass.

ISOLEUCINE TO LEUCINE AMINO ACID SUBSTITUTION IN PLASTIDIC ACCASE CONFERS RESISTANCE TO PINOXADEN HERBICIDE IN SOUTHERN CRABGRASS (*DIGITARIA CILIARIS*). S. Basak*[1], B. Bi[1], A. M. Brown[1], P. McCullough[2], J. S. McElroy[1]; [1]Auburn University, Auburn, AL, [2]University of Georgia, Griffin, GA (250)

ABSTRACT

Isoleucine to leucine amino acid substitution in plastidic ACCase confers resistance to pinoxaden herbicide in southern crabgrass (*Digitaria ciliaris*)

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Southern crabgrass (*Digitaria ciliaris* (Retz.) Koeler) is a competitive annual grass weed that commonly infests turfgrass, roadsides, wastelands and major cropping systems throughout the southeastern United States. Acetyl-coenzyme A carboxylase (ACCase) inhibiting herbicides including cyclohexanediones (CHD), aryloxyphenoxypropionates (AOPP), and pinoxaden are used as a selective graminicide for postemergence grass weed control in annual and perennial cropping systems. Two biotypes of southern crabgrass (R_1 and R_2) with confirmed resistant to CHD and AOPP were collected from sod production fields in Georgia. A susceptible biotype (S) was collected from Alabama. Studies were conducted to determine the primary mechanism for resistance in these two resistant biotypes and to determine if the resistance to pinoxaden herbicide was present in these two biotypes. Increasing rates of pinoxaden (0.09 to 23.5 kg a.i. ha^{-1}) were evaluated for control of R_1, R_2 and S biotypes. The resistant biotypes for CHD and AOPP herbicides were resistant to pinoxden at the lower rate relative to the susceptible biotype. The susceptible biotype was completely controlled at rates 11.8 and 23.5 kg a.i. ha^{-1} resulting in no aboveground biomass at 14 DAT. Pinoxaden rates at which tiller length and above-ground biomass would be reduced by 50% (I_{50}) and 90% (I_{90}) for R_1, R_2 and S ranged from 7.2 to 13.2, 6.9 to 8.7 and 0.7 to 2.1 kg a.i. ha^{-1}, respectively for tiller length and 7.7 to 10.2, 7.2 to 7.9 and 1.6 to 2.3 kg a.i. ha^{-1}, respectively for above-ground biomass. The amplification of the carboxyl-transferase domain of the plastidic ACCase by standard PCR and the transcriptome profiling by RNA sequencing revealed a single Ile-1781-Leu amino acid substitution in these resistant biotypes. Research, therefore, confirms that in addition to conferring resistance to CHD and AOPP herbicides, Ile-1781-Leu also confers resistance to pinoxaden.

Key words: Herbicide resistance, pinoxaden, turfgrass, polymerase chain reaction, next generation sequencing.

IMPACT OF CROP ROTATION, TILLAGE, AND HERBICIDE TREATMENT ON R:S RATIO OF ALS-RESISTANT KOCHIA AFTER FOUR YEARS. E. G. Mosqueda*[1], A. Kniss[1], N. C. Lawrence[2], P. Jha[3], G. Sbatella[4]; [1]University of Wyoming, Laramie, WY, [2]University of Nebraska-Lincoln, Pullman, WA, [3]Montana State University, Huntley, MT, [4]University of Wyoming, Powell, WY (251)

ABSTRACT

Kochia (*Bassia scoparia*) is problematic for growers throughout the Western United States, in part, because of evolved resistance to numerous herbicides. Field studies were conducted from 2014 through 2017 at sites in Wyoming, Montana, and Nebraska in order to quantify the combined impacts of crop rotation, tillage, and herbicide use on the evolution of herbicide resistant kochia. A known proportion of ALS-resistant kochia was established in 2014 before imposition of treatments. Tillage (main-plot) included annual intensive tillage or minimum tillage. Crop rotations (split-plot) consisted of continuous corn, corn-sugarbeet, corn-dry bean- sugarbeet, and corn-dry bean-small grain-sugarbeet. Herbicide treatments (split-split-plot) included complete reliance on ALS inhibitor herbicides, mixtures including ALS inhibitors, or an annual rotation which included ALS herbicides. Soil collected from each plot after 2017 harvest was placed in the greenhouse to initiate kochia emergence. Emerged kochia was counted and sprayed with chlorsulfuron when plants were 4 cm. Approximately 10 days after treatment, the number of surviving plants was recorded. Data was analyzed using a generalized linear mixed effects model and means were separated using Tukey's HSD (alpha=0.05) where appropriate. All main effects (tillage, crop rotation, and herbicide) affected kochia density ($P<0.001$), but only herbicide treatment had a marginal effect on R:S ($P=0.078$). Use of ALS-inhibitor mixtures resulted in the lowest R:S as well as the lowest density of resistant kochia (16 plants per m^{-2}) compared to the annual ALS rotation or complete reliance on ALS herbicides (113 and 144 plants per m^{-2}, respectively). Annual intensive tillage reduced resistant kochia density to 50 plants per m^{-2} from 81 plants per m^{-2} observed in minimum tillage. The most diverse (four crop rotation) and least diverse (continuous corn) crop rotations resulted in the lowest resistant kochia density (39 and 45 plants per m^{-2}) followed by the three- and two-crop rotation (79 and 117 plants per m^{-2}).

TARGET-SITE MUTATION IN *CONYZA CANADENSIS* BIOTYPES WITH EXTREME RESISTANCE TO GLYPHOSATE IN OHIO AND IOWA, USA. Z. T. Beres*[1], L. A. Giese[1], D. M. Mackey[1], M. D. Owen[2], E. R. Page[3], A. Snow[4]; [1]Ohio State University, Columbus, OH, [2]Iowa State University, Ames, IA, [3]Agriculture and Agri-Food Canada, Harrow, ON, [4]Ohio State University, Dept of EEOB, Columbus, OH (252)

ABSTRACT

The prolific use of herbicides has spurred the rapid evolution of multiple resistance mechanisms in agricultural weeds, and to date, at least 40 weed species have evolved resistance to glyphosate. Documenting the origin and distribution of glyphosate resistance mechanisms is important for understanding how to anticipate and mitigate weed management problems. In horseweed (*Conyza canadensis*), glyphosate resistance has been documented in 25 states within the USA and 12 countries worldwide. Several mechanisms for resistance have been documented in horseweed, but evidence for a mutation at EPSPS2 has only been reported in Ontario, Canada, to date. To test for this mutation in the USA, we sampled seeds from one maternal plant (= biotype) at each of 24 sites in north-central Ohio and 20 sites in southern Iowa. Because

horseweed is highly self-pollinating, all seeds from the same maternal plant are expected to be full-sibs. For comparison, we also analyzed ten previously sequenced and described pooled seed samples (= accessions) representing susceptible vs. resistant populations from Canada. Five herbicide treatments were used to assign biotypes/accessions to resistance categories based on 80% survival at 0x only (S = susceptible), and up to 1x (R1; equivalent to 840 g ae ha^{-1}), 8x (R2), 20x (R3), and 40x (R4). Based on EPSPS2 sequencing of individual plants (one per family), all 20 biotypes from Ohio and Iowa that were scored as S, R1, or R2 lacked a point mutation at position 185, while all biotypes that were scored as R3 or R4 had the same proline-to-serine substitution at position 185 (Ohio: 1 R3 biotype, 13 R4 biotypes; Iowa: 3 R3 biotypes, 8 R4 biotypes). This proline-to-serine mutation also was found in plants from the resistant accessions from Canada, which were ranked as R4 (i.e., extremely resistant), except for one accession that was inconsistent and segregated for the point mutation upon further analysis. To our knowledge, these findings represent the first documented case of target site mediated glyphosate resistance in horseweed in the United States, and the first to show that horseweed biotypes with this mutation are extremely resistant to glyphosate, tolerating at least 40x of the original effective dose. While the Ohio biotypes with the target site mutation originated from sites that were only 86 km from the nearest documented Canadian examples, it is noteworthy that the Iowa biotypes with the mutation were at least 700 km away from those sampled in Ohio and Canada. We hypothesize that this mutation may evolve repeatedly in horseweed populations that are frequently exposed to glyphosate, and may disperse rapidly *via* the weed's small, wind-dispersed seeds. A similar target site mutation has also been found as a mechanism for glyphosate resistance in several other weed species, typically designated as p106 of EPSPS2.

FERTILIZER PLACEMENTS AFFECT WEED GROWTH AND REPRODUCTION IN NURSERY CONTAINER PRODUCTION. D. Saha*[1], C. Marble[2], A. Chandler[1]; [1]Mid-Florida Research and Education Center, University of Florida, Apopka, FL, [2]University of Florida, Apopka, FL (253)

ABSTRACT

Placement of fertilizer in container nursery production can change the spatial availability of nutrients and affect weed growth. The objective of this research was to evaluate the effect of four fertilizer placements on weed growth and reproduction in soilless nursery substrates. Nursery containers (3.8L) were filled with substrate [Pinebark : sand 8:1 (v:v)] and 36.5 grams of controlled release fertilizer (Osmocote Plus 17-5-11) was added to every pot either by top-dressing, sub-dressing, dibbling, or incorporated with the substrate. A separate set of pots was included in the experiment in which no fertilizer was added. Twenty-five seeds of either spotted spurge (*Euphorbia maculata* L.), crabgrass [*Digitaria sanguinalis* (L.) Scop.], or eclipta [*Eclipta prostrata* (L.) L.] were sown on top of the substrate and pots were moved to received 1.3 cm of irrigation daily throughout the experiment. Data collection included weed counts at 3 and 8 weeks after seeding (WAS), and flower counts, shoot/root weights, and estimated seed counts at 8 WAS. All data were subjected to ANOVA by using PROC GLM method in SAS (9.4). Means were separated by Fisher's LSD test and P values were considered significant at ≤ 0.05. The greatest shoot and root weights were observed in when fertilizers were either topdressed or incorporated for all three weed species. Root growth took place when fertilizer was incorporated with the substrate for all the three weed species. In all three species, weed shoot and root weights were similar in pots that were subdressed, dibbled, or contained no fertilizer. Flower counts and estimated seed production followed a similar trend where the greatest flowering and seed production occurred in pots that were topdressed or incorporated and few differences were observed between pots that subdressed, dibbled, or contained no fertilizer. Results from these experiments show that when fertilizer is incorporated or topdressed with the substrate and used for the container crop production, weed growth and reproduction will be high whereas, sub-dressing and dibbling will provide maximum weed control.

SINGLE NUCLEOTIDE POLYMORPHISM IN PLASTID PROTOPORPHYRINOGEN OXIDASE GENE (PPO1) CONFERS RESISTANCE TO OXIDIAZON IN *ELEUSINE INDICA*. B. Bi*[1], Q. Wang[1], J. J. Coleman[1], J. S. McElroy[1], J. M. Peppers[2], N. Hall[1]; [1]Auburn University, Auburn, AL, [2]Auburn University, auburn, AL (254)

ABSTRACT

Goosegrass (*Eleusine indica* (L.) Gaertn) is a problematic weed in managed turfgrass in United States. Oxadiazon is a unique protoporphyrinogen oxidase (PPO) inhibitor ultilized for preemergence goosegrass control in various turfgrass and crops. Two PPO related genes (PPO1 and PPO2) of two oxadizon resistant (R1 and R2) and susceptible biotypes (S) were isolated by RNA sequencing. An amino acid substitution $Ala_{212}Thr$ of plastid PPO1 gene occurred in both R1 and R2 biotypes, without nonsynonymous substitutions occurring between mitochondria PPO2 of resistant and susceptible biotypes. A hemG mutant *E. coli* strain transformed with the plastid PPO1 gene from the resistant and susceptible biotypes can grow on the medium with up to 200μM oxadiazon, while the mutant *E. coli* strain transformed with the plastid PPO1 gene from the susceptible biotype can only grow on the medium with 10μM to 50μM oxadiazon. This is the first report that an amino acid substitution in PPO1 can confer weed resistant to oxadiazon. Other research indicates $Ala_{212}Thr$ in PPO1 does not confer resistance to sulfentrazone, lactofen, or flumioxazin.

EVALUATION OF THE SUITABILITY OF 13 SUMMER COVER CROP SPECIES FOR SOUTHEAST TEXAS. S. L. Samuelson*, M. V. Bagavathiannan; Texas A&M University, College Station, TX (255)

ABSTRACT

With the increased dependence on herbicides and the proliferation of herbicide-resistant weed species, alternative methods of weed control are of great interest and demand. Cover crops have been a successful addition to manage troublesome weeds in North Central and North Eastern United States, but still have unused potential in the Southwestern regions of the US. The objectives of this study were to determine which cover crop species offer the greatest impact on weed suppression, overall biomass accumulation, and to assess the cover crops impact on soil moisture dynamics. Thirteen summer cover crop species were planted at the Texas A&M University research farm near College Station, TX in August 2017 & 2018 and arranged in a randomized complete block design with four replications. Plots measured 3.5 x 9 m^2. Ground cover and cover crop density measurements were estimated along with weed infestation (%) and density (number m^{-2}) at 21 days after planting and at cover crop termination, or after the first killing frost. Soil moisture content was recorded at weekly intervals at 10, 20, 30, and 40 cm depths. Further, surface soil temperature was also documented at each observation. Weed and cover crop above ground biomass were separated, dried, and recorded at cover crop termination. Winter annual weed emergence was documented and then harvested for biomass during the last week of February. The summer annual cover crops such as sunn-hemp, sorghum-sudangrass, buckwheat, and cowpeas showed promising results with respect to weed suppression and moisture demand. Results from this assessment will help in developing effective cover crop systems for this region. (muthu@tamu.edu)

INVESTIGATION OF METABOLISM ASSOCIATED WITH QUIZALOFOP RESISTANCE IN COAXIUM WHEAT. R. A. Bough*, F. E. Dayan, T. Gaines; Colorado State University, Fort Collins, CO (256)

ABSTRACT

CoAXium winter wheat is resistant to the active form of the proherbicide quizalofop-p-ethyl, a selective inhibitor of grass species. Resistance is conferred by a novel point mutation in one to three acetyl-CoA carboxylase homoeologs (AABBDD, 2n=6x=42). The mutation originates from ethyl methanesulfonate mutagenesis and phenotypic selection. Initially, additive resistance relative to the number of mutant homoeologs was proposed, however, recent investigations suggest the target-site resistance (TSR) is non-additive. In greenhouse studies, accessions with either two identical or three mutations reveal differential resistance as well as greater resistance for two versus three mutations. Resistance variation also occurs in spring wheat accessions introgressed with resistance mutations. The addition of cloquintocet safener did not improve spring wheat resistance for labeled herbicide rates (62-92 g ai ha^{-1}). Liquid-chromatography mass-spectrometric assays of active herbicide content in plant tissue over time demonstrate some differences in detoxification by single mutants and between mutants with identical double mutations or triple mutations. Safener facilitates herbicide detoxification across both winter and spring wheat double mutants, especially at three days after herbicide application. The non-additive nature of the novel TSR indicates that double mutant wheat accessions may be preferable to triple mutants. Variation in herbicide detoxification rates implies that metabolic factors are involved with overall resistance.

ASSESSING DICAMBA INJURY ACROSS DIFFERENT SOYBEAN VARIETIES AND MATURITY GROUPS. E. A. Jones*[1], W. Everman[1], J. Sanders[2], D. J. Contreras[1], M. A. Granadino[1]; [1]North Carolina State University, Raleigh, NC, [2]North Carolina State University, Holly Springs, NC (257)

ABSTRACT

Dicamba use has increased recently to control herbicide-resistant weeds. Increasing the use of any herbicide can increase the likelihood of off-target damage. Soybeans express high susceptibility to dicamba at very low doses. Different soybean maturity groups and varieties are planted to cater to the characteristics to the specific environment. The differing varieties and maturity groups may have variable tolerance to sub-lethal rates of dicamba, thus incurred injury levels may vary between each biotype. The objective of the research was to determine if different soybean varieties and maturity groups incurred more injury at vegetative and reproductive stages and if the incurred injury was also influenced by an early or late planting dates. The experiment was conducted at Kinston and Rocky Mount, North Carolina in 2018. Soybeans from two maturity groups (V and IV) and two varieties per maturity group were planted in May or June at both experiment sites. Dicamba was applied at 0.0, 1.08, 4.35, and 17.40 g ae ha^{-1} to soybeans during a vegetative stage (V4) and a reproductive stage (R2) at each respective planting date. Weekly visual evaluations of injury were conducted 14, 21, 28, and 35 days after treatment (DAT). There no was difference of injury between the soybean maturity groups and varieties at all plantings and application timings, but the injury was different between locations. The vegetative stage soybeans incurred more injury across all rates than the reproductive soybeans at all evaluation timings and planting dates except for 35 DAT. The result of the experiment provides evidence that tested soybean maturity groups and varieties do not effect the tolerance to dicamba and vegetative soybeans will incur more injury than reproductive soybeans at earlier and later planting dates.

GENETIC DIVERSITY AND MOLECULAR MARKERS FOR ABIOTIC STRESS TOLERANCE IN WEEDY RICE. S. D. Stallworth*[1], T. Tseng[1], S. Shrestha[2], B. C. Schumaker[2]; [1]Mississippi State University, Mississippi State, MS, [2]Mississippi State University, Starkville, MS (258)

ABSTRACT

As global temperatures continue to rise and fluctuate, it is imperative that crop breeding programs continue to improve. In regions where rice is the staple food product, impacts from cold, heat, and submergence stress could be devastating and felt for generations to come. In rice, it has been demonstrated that exposure to higher than 38C for 8 hours or more can completely wipe out a rice harvest. Others have found that temperatures greater than 34C can cause spikelet infertility resulting in a yield reduction of up to 60%. Cold stress, at temperatures below 17C, can result in poor germination, seedling injury, and reduced yield. Moreover, in areas where flash flooding is unpredictable, submergence stress in rice fields can lead to a 10-100% yield loss. Due to the high impact value of rice, discovering abiotic stress tolerant rice cultivars is necessary to ensure economic stability. Currently, rice breeding programs lack genetic diversity and suffer from a loss in traits through domestication. To combat these shortcomings, it has been suggested that weedy rice, a noxious subspecies of rice with increased competition within rice fields, and high genetic diversity, can potentially be used for the discovery of novel genes related to abiotic stress tolerance. In this study, a population of 54 weedy rice accessions were selected and phenotypically screened for responses to cold, heat, and submergence stress tolerance. Selected accessions that performed better than rice cultivars were used in a simple sequence repeat (SSR) marker study containing 30 SSR markers to discover markers associated with tolerance to the selected stresses. Screenings show that all markers were polymorphic with an average genetic diversity of 44% amongst the 54 weedy rice accessions. For the three stresses analyzed, the average genetic diversity among the selected population was 41.37%. For cold, heat, and submergence stress screening, diversity was 41.27, 37.86, and 37.65, respectively. Specific clusters were identified within the population that showed separation between the tolerant weedy rice lines and the susceptible rice cultivars. To further analyze the population, additional markers will be screened to better notate patterns associated with tolerance within the weedy rice population. Successful identification of SSR markers associated with abiotic stress tolerance in weedy rice could lead to rapid identification of tolerant rice cultivars and better improve marker-assisted breeding techniques.

LEPTOCHLOA ACUMINATA CLOMAZONE METABOLISM IN CALIFORNIA RICE. K. E. Driver*[1], C. A. Brunharo[2], A. Godar[1], K. Al-Khatib[1]; [1]University of California, Davis, Davis, CA, [2]Oregon State University, Corvallis, OR (259)

ABSTRACT

The culture of California rice production is heavily dependent on herbicides and has limited crop rotation. These practices combined have led to widespread herbicide resistance. Recently, clomazone resistant bearded sprangletop (*Leptochloa acuminata)* was confirmed in California rice. Studies on level of resistance were conducted and a rate response was documented. Further testing on the absorption, translocation, and mechanism of resistance have been performed. Absorption and translocation studies used completely randomized design. ^{14}C clomazone was applied to bearded sprangletop leaves and harvested at 36 and 72 HAT. Mechanism of resistance studies used a randomized complete block design with a factorial treatment structure; factor 1 being population and factor 2 being treatment. Three populations were used; a known susceptible and 2 resistant populations. Treatments included 1) a nontreated check, 2) malathion at 1583 g ai ha^{-1}, 3) clomazone at 594 g ai ha^{-1}, 4) malathion fb clomazone 24 HAT, and 5) malathion fb clomazone 24 HAT fb malathion 48 HAT. Visual assessments were made weekly for 3 WAT. No differences were observed in absorption or translocation of clomazone in bearded sprangletop populations at 36 or 72 HAT. Resistant plants treated with malathion fb clomazone 24 HAT exhibited severe bleaching symptoms followed by plant death, indicating metabolic resistance as the mechanism of resistance.

METABOLIC RESISTANCE TO *S*-METOLACHLOR IN TWO MULTIPLE HERBICIDE-RESISTANT WATERHEMP POPULATIONS FROM ILLINOIS. S. Strom*[1], L. Gonzini[1], C. Mitsdarfer[1], A. S. Davis[2], D. E. Riechers[3], A. Hager[1]; [1]University of Illinois, Urbana, IL, [2]N-319 Turner Hall, Urbana, IL, [3], Urbana, IL (260)

ABSTRACT

S-metolachlor has been widely used for preemergence (PRE) control of annual grasses and small-seeded broadleaves in crops such as corn, soybean, and cotton since its commercialization in the 1990s. Previous field research on two multiple herbicide-resistant (MHR) waterhemp (*Amaranthus tuberculatus*) populations (MCR and CHR) from Illinois demonstrated poor control with *S*-metolachlor. Further research at the CHR site (2016–2017) revealed very few effective Group 15 herbicide options, with *S*-metolachlor providing 27% or less control 28 days after treatment (DAT). CHR and MCR are MHR to *s*-triazines, HPPD-, and ALS-inhibitors. Responses of progeny generated from each population (named CHR-M6 and MCR-NH40) to *S*-metolachlor were compared to two *S*-metolachlor-sensitive populations (ACR and WUS) in greenhouse dose-response experiments. Resistant-to-sensitive ratios (R/S) based on biomass reduction (GR_{50}) were 7.5 and 12.9 for CHR-M6 and MCR-NH40, respectively, when compared to WUS, and ratios increased in comparison to ACR. The similarities between CHR and MCR led us to hypothesize that a physiological factor within the plant, such as rapid metabolism, was responsible for the decreased control with *S*-metolachlor. Investigation of radiolabeled *S*-metolachlor metabolism was conducted in seedlings from the CHR and MCR populations in comparison to WUS, ACR, and corn. Qualitatively, thin layer chromatography (TLC) revealed that CHR and MCR seedlings metabolized *S*-metolachlor faster than either sensitive population 2–24 hours after treatment (HAT). Within the 24-hour time course, complete conversion of parent *S*-metolachlor to more polar metabolites was observed in CHR and MCR, and their metabolite profiles were different from either sensitive population or corn. The current corroboration of field, greenhouse, and metabolism experiments indicates that the CHR and MCR populations have developed metabolic resistance to *S*-metolachlor. Future research is planned for metabolite quantification, identification, and investigation of the putative enzyme(s) involved.

INVESTIGATING CROSS-RESISTANCE TO THE SYNTHETIC AUXINS FLUROXYPYR AND DICAMBA IN KOCHIA SCOPARIA. O. E. Todd*[1], T. Gaines[1], D. Pettinga[2], P. Westra[1]; [1]Colorado State University, Fort Collins, CO, [2]Colorado State University, fort collins, CO (261)

ABSTRACT

Fluroxypyr and dicamba are synthetic auxin herbicides used to control *Kochia scoparia* in cereal grains, fallow and rangeland with field use rates of 280 g ai/ha and 560 g ai/ha respectively. Multiple U.S. states have reported dicamba resistance in *Kochia scoparia* and three cases are reported cross-resistant to dicamba/fluroxypyr. A greenhouse fluroxypyr dose response ranging from 0 to 2240 g ai/ha was conducted on three lines: a fluroxypyr resistant line (flur-R) isolated from an eastern Colorado field survey; a dicamba resistant/fluroxypyr susceptible line (9425); and a dicamba/fluroxypyr susceptible line (field-S). After two rounds of greenhouse dose response selection and seed bulking of individuals surviving 1x, 2x and 4x fluroxypyr rates, the fluroxypyr resistance trait in flur-R is nearly homogenous. Results from the most recent dose response indicate that the rate required to control 50% of the flur-R population (LD50) was 882 g ai/ha and flur-R was 21 times more resistant than 9425, (pvalue = <.001). In an effort to investigate cross-resistance in flur-R, a pilot dicamba dose response (no adjuvant) testing the flur-R line caused 50% reduction in growth (GR50) at a rate 1462 g ai/ha. However, only 11 fluroxypyr resistant individuals survived a dicamba dose at 280 g ai/ha or higher. Future directions for this research include repeating the dicamba dose response using NIS, to investigate both previously reported fluroxypyr/dicamba cross-resistance mechanisms and investigate novel mechanisms of resistance using transcriptomics. The result of these dose responses confirms fluroxypyr resistance, but whether flur-R is cross-resistant to dicamba remains unclear.

A NOVEL KENTUCKY ADAPTED RED CLOVER LINE DISPLAYS INCREASED 2,4-D TOLERANCE. L. P. Araujo*, M. Barrett, T. Pfeiffer, L. D. Williams, G. Olson; University of Kentucky, Lexington, KY (262)

ABSTRACT

Incorporation of a legume, such as red clover (*Trifolium pratense*), into grass-based pasture systems offers many benefits. However, available red clover lines are highly susceptible to herbicides, including 2,4-D (2,4-dichlorophenoxyacetic acid), which are used for broadleaf weed management in pastures. A novel red clover line, UK2014, was developed at the University of Kentucky through conventional breeding and it expresses higher tolerance to 2,4-D than Kenland, a common variety used by Kentucky's forage producers. Adopting this new tolerant line would broaden weed management options in a legume-grass mixed pasture. The objective of this study was to assess the field performance of UK2014, in terms of yield and 2,4-D tolerance level, and to evaluate the tolerance of UK2014 to grazing in a clover-grass mixture following 2,4-D treatments.

UK2014 and Kenland were seeded in April 2017 in Lexington, KY. Treatments consisted of 2,4-D at a low and a high rate (1.12 and 2.24 kg/ha, respectively), applied either early (July), mid (August) or late (October) season. Each plot received only one 2,4-D treatment and treated plots were compared to controls that were not treated with 2,4-D. The entire experiment was repeated in 2018. Visual herbicide injury was evaluated one week after spraying. A visual injury rating scale from zero (no observed injury) to 100 (death of all plants in the plot) was used. Plots were harvested one week after treatment. Visual regrowth estimates were taken 14 days after treatment (7 days after harvest), also using a visual rating scale from zero to 100. Both individual harvest and total season yields (dry matter ton/a) were determined. In April 2018, a grazing tolerance study was estabilished in Lexington, KY. UK2014 and Kenland were interseeded in a tall fescue (*Festuca arundinacea*) pasture. In May 2018, 2,4-D treatments were applied at 1.68 kg/ha. The plots were mob grazed with cattle in July 19, August 9, and September 11. Red clover and fescue heights, clover stand, and clover dry weight in the forage mixture were measured at grazing dates. Clover stands were evaluated in a 0 (weak) to 5 (very strong) visual scale. Clover dry weights were determined in two subsamples from each plot and expressed as a percentage of the total subsample weight. Data was subjected to analysis of variance and means were separated by Fisher's Protected LSD at $\alpha = 0.05$.

In 2017, visual injury one week after 2,4-D treatment was less for UK2014 than Kenland, at all treatment dates. Similarly, in plots treated with 2.24 kg/ha 2,4-D, visual estimates of regrowth were higher for UK2014 than Kenland. However, there were no differences in yield between UK2014 and Kenland at individual harvests or in the season total. While this indicated that the performance of UK2014 is equal to Kenland in terms of yield, it also indicated that the 2,4-D injury to Kenland was not enough to reduce its yield. In 2018, UK2014 again had lower injury ratings and higher regrowth ratings than Kenland treated plots. However, unlike in 2017, the early 2,4-D early treatment reduced Kenland yield compared to the untreated Kenland. In the grazing study, 2,4-D treatment reduced the stand of UK2014 approximately 25% but the Kenland stand was reduced approximately 75% by the 2,4-D. There was no interaction with grazing for the stands of the two varieties.

INTEGRATING CROP ROTATION AND HERBICIDE PROGRAMS TO CONTROL KOCHIA AND PALMER AMARANTH IN SUGARBEET. C. W. Beiermann*[1], N. C. Lawrence[2]; [1]University of Nebraska-Lincoln, Scottsbluff, NE, [2]University of Nebraska-Lincoln, Pullman, WA (263)

ABSTRACT

With few effective herbicides registered in sugarbeet, production relies heavily on glyphosate for weed control. Glyphosate-resistant kochia (*Bassia scoparia*) has become prevalent within the High Plains sugarbeet production region and glyphosate-resistant Palmer amaranth (*Amaranthus palmeri*) is an emerging issue. Integration of

multiple-year cultural and herbicide management strategies is necessary to control glyphosate-resistant kochia and Palmer amaranth in sugarbeet. A trial was conducted to compare different herbicide combinations applied within three common rotational crops: corn, dry bean, and a small grain cereal. Sugarbeet was planted the following season and received two POST applications of glyphosate, ethofumesate PRE fb two POST applications of glyphosate + triflusulfuron methyl, or were untreated. At the end of the season weed density and biomass, and sugarbeet yield were assessed. In the 2018 sugarbeet crop, untreated plots had similar kochia density and biomass to treated plots when saflufenacil + dimethenamid-P was applied in corn the year before. In 2018 sugarbeet following dry bean, Palmer amaranth density and biomass increased when kochia and common lambsquarters (*Chenopodium album*) density and biomass decreased, subsequently effective early season weed control led to later flushes of Palmer amaranth and complicated analyses. Sugarbeet yield was effected in all cases by herbicide treatment in sugarbeet. There was limited additional benefit in yield from treatment including ethofumesate and triflusulfuron methyl. There was no effect of rotational crop herbicide treatment on sugarbeet yield.

COMPARISON OF SOYBEAN INJURY AND YIELD RESPONSE TO LOW-DOSE DICAMBA PARTICLE DRIFT AND VAPOR. F. B. Browne*, S. Li, K. J. Price; Auburn University, Auburn, AL (264)

ABSTRACT

Recent commercial launch of new dicamba technology has led to increased applications in row crops and high numbers of drift complaints across the US. Dicamba off-target movement can occur through particle drift, vapor drift, or tank contamination. However, the source and dosage of dicamba are often difficult to determine and observable symptomology is not always associated with yield loss. Field studies were conducted in Macon County, AL to compare sensitive soybean response to simulated dicamba particle and vapor drift. Broadcast applications of dicamba at 0.03, 0.07, 0.14, 0.70, 1.40, 3.51, 6.84, 14.03, 35.07, and 140.28 g ae ha^{-1} were used to simulate particle drift in 2017 and 2018. Vapor drift was simulated in 2018 through plastic tunnels placed over two rows of soybean to concentrate vapor emitted from soil pans treated with dicamba at 0.56, 5.59, 56.42, 559.17, 5591.75, and 11183.51 g ae ha^{-1}. Visual injury was recorded at 1, 3, 7, 14, and 21 days after treatment (DAT) in addition to yield at harvest. Furthermore, foliar concentrations of dicamba were analyzed at 1, 7, and 21 DAT in 2017. Low dicamba concentrations were detected up to 21 DAT. However, data indicate 84-92% of initial concentrations are metabolized within the first 7 days. Soybean visual injury resulted from particle drift steadily increased with higher dosages up to 90% for 140.28 g ae ha^{-1}. Compared to the non-treated control, yield losses resulted from particle drift were correlated to dosage with losses of 7% at 0.70 g ae ha^{-1} increasing to 90% at 140.28 g ae ha^{-1}. Alternatively, soybean visual injury resulted from vapor exposure did not exceed 43% regardless of dosage and yield was not significantly reduced. Soybean response to dicamba particle drift was not comparable to vapor exposure. For example, 48-56% injury resulted from particle drift was associated with 64-65% yield reductions in both years. However, 43% injury resulted from vapor exposure was not associated with yield loss. Data suggests visual injury is a poor indicator of yield loss and soybean response is likely to vary with different sources of non-target exposure. Additional research will be needed to fully understand the impact of dicamba drift on sensitive soybeans. Preservation of this technology will depend on proper stewardship to minimize off-target movement.

PALMER AMARANTH GROWTH AND FECUNDITY IN COMPETITION WITH VARIOUS ROW CROPS IN NORTH CAROLINA. D. J. Mahoney*[1], D. Jordan[2], A. T. Hare[2], N. R. Burgos[3], K. M. Jennings[2], R. Leon[2], M. C. Vann[2]; [1]North Carolina State University, Cary, NC, [2]North Carolina State University, Raleigh, NC, [3]University of Arkansas, Fayetteville, AR (265)

ABSTRACT

Palmer amaranth (*Amaranthus palmeri* S. Wats.) is regarded as one of the most troublesome weeds in crop production due to its rapid growth rate, competitive abilities, and immense fecundity that can replenish the soil seed bank in a single generation. Research has been conducted on the growth and fecundity of Palmer amaranth; however, the majority of work occurred in the midwestern and mid-southern states. Additionally, these parameters have mostly been evaluated when Palmer amaranth is not competing with crops or only in one cropping system. Therefore, research was conducted to determine the growth and fecundity of Palmer amaranth in competition with various row crops in North Carolina to address these knowledge gaps. Corn, cotton, peanut, and soybean were planted in two fields at the Upper Coastal Plain Research Station (Rocky Mount, NC) into conventionally-prepared seed beds on 91-cm spacings. A randomized complete block design was utilized in order to allow for direct comparison of Palmer amaranth growth and fecundity across crops. One week after planting (WAP), eight Palmer amaranth seedlings were selected per plot with a 2 m^2 weed-free area (only crop competition) to mitigate weed competition. Eight were selected to ensure at both male and female plants were available for season long measurements. Two WAP, the selected plants were covered with cups and the field was treated with glyphosate plus glufosinate (868 + 451 g ae/ai ha^{-1}) in corn and cotton. In soybean, only glyphosate (1,104 g ha^{-1}) was applied while paraquat plus bentazon (140 + 561 g ha^{-1}) was utilized in peanut. Plots were kept weed-free by hoeing and hand-weeding beyond these applications. Height and width of Palmer amaranth were measured eight times throughout the season with biomass measured in September. Female plants were collected and dried at the Method Road Greenhouse Complex (Raleigh, NC) in order to determine seed production.

The main effects of crop and gender were significant with respect to at-harvest plant height. When averaged over gender, Palmer amaranth which emerged with corn (219 cm) was taller than cotton (199 cm). Palmer amaranth height in peanut (177 cm) and soybean (174 cm) were similar and less than the two aforementioned systems. Pooled over crop, female plant height (200 cm) exceeded their male (184 cm) counterparts. When Palmer amaranth height to width ratio was analyzed, corn > soybean > cotton = peanut at every time point. A crop by gender interaction was significant for at-harvest Palmer amaranth biomass. Female plants in cotton (2,014 g) and peanut (1,879 g) were greater than their male counterparts (934 and 879 g, respectively). Male and female plants in corn (77 and 195 g, respectively) and soybean (258 and 434 g, respectively) were similar and less than the aforementioned plants. Preliminary seed production estimates revealed Palmer amaranth plants in cotton and peanut produced approximately 625,500 and 569,900 seeds $plant^{-1}$, respectively. When competing with soybean, female plants produced approximately 213,500 seeds $plant^{-1}$ while in corn, production was approximately 65,800 seeds $plant^{-1}$. These data suggest, corn and soybean are more competitive with Palmer amaranth than cotton and soybean. It may be hypothesized that Palmer amaranth had to focus photosynthetic energy growing taller (height to width ratio) with corn and soybean to compete for sunlight thus reducing biomass and seed production compared to cotton and peanut. The data illustrate the critical need for controlling Palmer amaranth in crop production because of immense fecundity. It also suggests that in fields where Palmer amaranth is more problematic, corn or soybean provide increased competition compared to cotton and peanut which may be implemented into a more thorough integrated weed management plan.

EVALUATING EFFECTIVENESS OF DICAMBA REMOVAL FROM CONTAMINATED SPRAYERS FOLLOWING VARIOUS INCUBATION PERIODS FROM CONTAMINATION TO CLEAN OUT. Z. A. Carpenter*, D. B. Reynolds, A. B. Johnson; Mississippi State University, Mississippi State, MS (266)

ABSTRACT

The release of dicamba tolerant soybeans allows growers to control troublesome glyphosate resistant weeds; however, several challenges are also forthcoming, one being sprayer hygiene. Glyphosate is water soluble, allowing it to be easily removed from spray tanks through three rinses with water alone. Synthetic auxin herbicides are not as water soluble and therefore can be difficult to completely remove from sprayer components. Additionally, many crop species are highly sensitive to synthetic auxins at very low concentrations. The objective of this study was to determine the effectiveness of standard sprayer cleanout methods following various incubation periods from

contamination with dicamba to the time of cleanout. Cleanouts were conducted in 2017 and 2018, with field experiments being conducted in Brooksville and Starkville, MS in 2018. Treatments consisted of various incubation timing (0, 24, 48, 72, and one week) and cleaner used (wipeout and water). A small-scale sprayer was designed to replicate the cleanout procedures used on commercial sprayers. The system was first contaminated with dicamba (Xtendimax) at 560 kg ae ha^{-1} and rhodamine WT dye at 0.2% v/v. Following an incubation period, the sprayer then underwent a 3-rinse cleanout, utilizing one of the tank cleaners during the second rinse step. During each rinse, the solution was recirculated through the system for 15 minutes and samples were collected for both field and lab analysis. Once the sprayer was cleaned using the triple rinse procedure it was filled with an 867 g ae ha^{-1} rate of glyphosate (Roundup Powermax), and another sample was collected. All samples were sprayed over actively growing non-dicamba tolerant soybeans (*Glycine max* L.) at the R1 growth stage. Visual ratings for phytotoxicity were taken 7, 14, 21, and 28 DAT and plant heights were taken 14, 21, and 28 DAT. Samples collected during each rinse were analyzed using HPLC to determine auxin herbicide concentrations as a means to evaluate cleanout efficacy. Plants were harvested at end of the growing season for yield. All data were subjected to ANOVA using the PROC GLIMMIX procedure in SAS 9.4 and means were separated using Fisher's Protected LSD at α=0.05. Data reveal that visual injury incrementally decreased from 65% during the first rinse to under 20% at the glyphosate rinse, with the 48-hour, 72-hour, and 1-week incubation timing producing significantly more injury than the untreated check. Plant heights did not differ from the untreated check following the first rinse. The main effects of incubation time and cleaner did not significantly influence soybean yield reductions. Following the first rinse no significant reductions in soybean yield occur. Averaged across rinses and cleaners, all incubation times resulted in yield reductions of <10%. HPLC analysis of this spray solution confirmed that analyte concentration did not differ among tank incubation time, with all solutions containing less than 1 PPM by the third rinse. These data would indicate that a triple rinse system is necessary to achieve analyte concentrations low enough to avoid losses. These data also show that no differences were detected among the cleaners and incubation times tested in regard to effectiveness.

RESPONSE OF WHITE AND YELLOW POPCORN HYBRIDS TO PRE- AND POST-EMERGENCE HERBICIDES. E. R. Barnes*[1], N. C. Lawrence[2], S. Z. Knezevic[1], O. R. Rodriguez[3], S. Irmak[1], A. J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Pullman, WA, [3]Conagra Foods, Inc, Brookston, IN (267)

ABSTRACT

While a considerable amount of research has been conducted on field corn and sweet corn sensitivity to a number of herbicides, there is a lack of data and information in the scientific literature in terms of popcorn sensitivity to herbicides. Field experiments were conducted at the University of Nebraska–Lincoln, South Central Agricultural Laboratory, near Clay Center, NE, in 2017 and 2018 to evaluate labeled yellow popcorn herbicides in commercially available yellow and white popcorn hybrids for weed control and crop response as well as plant growth and yield. The experiments were arranged in a split-plot design with three replications. The main plot treatments consisted of eight commercially available hybrids. Ten sub-plot treatments consisted of an untreated control, weed-free control, and four PRE followed by (fb) POST herbicide programs that were applied at: 1) recommended rates (1X) and 2) double the recommended rates (2X). Herbicide programs included pyroxasulfone/fluthiacet fb dicamba/tembotrione, acetochlor/atrazine fb mesotrione/fluciacet, saflufenacil/dimethamid-P fb diflufenzopyr/dicamba, and clopyralid/acetochlor/mesotrione fb topramezone/dimethenamid-P. All PRE herbicides resulted in greater injury than the non-treated control (4-10% injury); however, 2X saflufenacil/dimethamid-P resulted in the greatest injury (10%) 21 days after (DA) PRE. Hybrids R265 and VYP315 resulted in the greatest injury following PRE application (8-11%). Saflufenacil/dimethamid-P fb diflufenzopyr/dicamba (2X) resulted the greatest lodging 60 DA POST (22%). Lodging 60 DA POST was greatest in VYP220, N1H820, SH3707W (18-23%). At labeled rates, clopyralid/acetochlor/mesotrione provided greatest control of velvetleaf (98%) 28 DAPRE. All PRE herbicides at labeled rates, except pyroxasulfone/fluthiacet, provided excellent (95 to 99%) control of common lambsquarters 28 DA PRE. Common waterhemp and Palmer amaranth were controlled 94 to 99% and 98 to 99% from all herbicides at labeled rates 28 DA PRE, respectively. Grasses in 2017 were control 95 and 98% from labeled rates of pyroxasulfone/fluthiacet and clopyralid/acetochlor/mesotrione, respectively. In 2018 grasses were control 87 to 90% 28 DA PRE from all herbicides, except pyroxasulfone/fluthiacet. Broadleaf weed control ranged from 95 to 99% from all herbicides at labeled rates 21 DA POST. The greatest grass weed control 21 DA POST was achieved from acetochlor/atrazine fb mesotrione/fluciacet and clopyralid/acetochlor/mesotrione fb topramezone/dimethenamid-P in 2017 and from clopyralid/acetochlor/mesotrione fb topramezone/dimethenamid-P in 2018. Weed biomass reduction ranging from 90 to 98% and from 68 to 97% was achieved from all herbicide programs in 2017 and 2018, respectively. Yield losses ranged from 0 to 7.2% across all herbicide treatments except the nontreated control which resulted in 42.2% yield loss compared to the weed free control. Although hybrid differences to herbicide tolerance were detected, the differences did not appear to be linked to hybrid kernel color. Broadleaf weed control was achieved with all herbicide programs; however, grass weed control was poor for all programs, except clopyralid/acetochlor/mesotrione fb topramezone/dimethenamid-P. These data and information will be of immediate impact to popcorn producers.

2,4-D METABOLIC RESISTANCE IN WATERHEMP (*AMARANTHUS TUBERCULATUS*). M. Figueiredo*[1], A. Kuepper[2], D. Giacomini[3], M. Jugulam[4], G. Kruger[5], P. Tranel[6], F. E. Dayan[1], P. Westra[1], T. Gaines[1]; [1]Colorado State University, Fort Collins, CO, [2]Bayer Crop Science, Frankfurt, Germany, [3]University of Illinois, Urbana, IL, [4]Kansas State University, Manhattan, KS, [5]University of Nebraska-Lincoln, North Platte, NE, [6]University of Illinois, Urbana, IL (268)

ABSTRACT

Selectivity to 2,4-D (2,4-Dichrophenoxyacetic acid) in monocotyledonous species is associated with rapid metabolism by non-reversible ring hydroxylation, while in sensitive dicotyledonous species the herbicide is usually metabolized via a reversible amino acid conjugation. A 2,4-D resistant population of common waterwemp (*Amaranthus tuberculatus*), described for its capacity of rapid herbicide metabolism, was studied. First, the metabolic profile between susceptible and resistant plants was characterized using radiolabeled 2,4-D. In susceptible plants, just one metabolite formed, while in resistant, two metabolites were produced having differential retention time on LC. All metabolites were purified and chemically characterized by MS-MS and NMR. In susceptible plants, the metabolite was characterized as 2,4-D aspartic acid and in resistant plants, the herbicide metabolite had ring hydroxylation followed by sugar and malonyl conjugation. Hydroxylation reactions are usually catalyzed by cytochrome 450 enzymes, thus an RNAseq experiment was performed using pseudo F2 waterhemp, in order to characterize P450s that would show overexpression and/or mutations in resistant plants. A region in the beginning of chromosome 4 was identified containing several nucleotide variants in all the resistant plans tested. Three P450s were identified in this region and one showed overexpression in resistant plants. The expression and nucleotide variants were confirmed by qRT-PCR and Kompetitive Allele-Specific PCR (KASP) on 288 resistant and 96 susceptible pseudo F2 waterhemp plants. In this work, we show the first case that 2,4-D is hydroxylated in a dicotyledonous resistant species, by reactions that are more common to monocotyledonous tolerant species. This work opens new possibilities to elucidate mechanisms of metabolism-based herbicide resistance.

BICYCLOPYRONE EFFICACY IN SWEET CORN. T. L. Burke*, R. Zuger, I. C. Burke; Washington State University, Pullman, WA (269)

ABSTRACT

Corn growers in central Washington often encounter weeds not encountered in corn production in the central United States. Russian-thistle, a common and troublesome weed in dryland wheat production areas in eastern Washington sometimes infests irrigated sweet corn production areas in central Washington. An investigation was conducted of a new herbicide active ingredient, bicyclopyrone, for the control of broadleaf weeds, including Russian thistle, in irrigated sweet corn grown in the Columbia River Basin of Washington. Bicyclopyrone represents a new active ingredient of the hydroxyphenylpyruvate dioxygenase (HPPD) inhibitor class of herbicides, which could strengthen integrated herbicide management systems. Therefore, the objective was to evaluate bicyclopyrone efficacy in comparison to currently used herbicides. All

treatments were applied preemergence in spring of 2015, 2016, and 2018. Primary and total ear number was significantly greater for all herbicides compared to corn not treated with herbicides. Mid-summer Russian-thistle control in 2015 and 2016 was greater for both the dimethenamid-P plus atrazine treatment as well as the pyroxasulfone plus fluthiacet and atrazine treatment, compared to the pyroxasulfone plus carfentrazone and saflufenacil treatment, both the greater and lesser sets being similar to the bicyclopyrone treatments. Early summer purslane control in 2018 was similar to nontreated for all herbicides except saflufenacil plus dimethenamid-P; by late summer, all herbicide treatments, including bicyclopyrone, were similar and provided greater control than nontreated (>98%). All herbicide treatments, including the bicyclopyrone treatments, were similar for mid-summer common lambsquarters control in 2016 (≥96%), summer nightshade control in 2015 (≥98%), late-summer Russian-thistle control in 2015 and 2016 (≥78%), spring and summer pigweed control in 2018 (≥80%). As supported by both crop response and weed control, bicyclopyrone functions comparably to currently used herbicide options for Russian-thistle, common lambsquarters, purslane, and pigweed control in sweet corn in central Washington.

CAN OFF-TARGET MOVEMENT OF DICAMBA BE REDUCED WITH SEE & SPRAY TECHNOLOGY? Z. D. Lancaster*[1], J. K. Norsworthy[1], J. T. Richburg[2], T. Barber[3]; [1]University of Arkansas, Fayetteville, AR, [2]University or Arkansas, Fayetteville, AR, [3]University of Arkansas, Lonoke, AR (270)

ABSTRACT

The rise of herbicide resistance increasingly challenges current production practices across multiple cropping systems in the Midsouth. Dicamba-resistant soybean and cotton varieties are currently available that allow dicamba use in crop. Over the past two years, off-target movement of dicamba has been a major issue for Arkansas producers. Blue River Technologies is currently developing a See & Spray technology that utilizes computer vision and machine learning to make selective herbicide applications to individual weeds. Reduced herbicide product per acre along with proprietary nozzle design could lead to a reduction in off-target movement of herbicides. A study was conducted in the summer of 2018 at the Northeast Research and Extension Center near Keiser, AR to compare the off-target movement of dicamba when applied using See & Spray technology compared to a current standard commercial application. Simultaneously, a See & Spray applicator and a commercial sprayer applied dicamba at 560 g ae ha^{-1} + glyphosate at 867 g ae ha^{-1} to 12 rows by 91.4 m of XtendFlex cotton surrounded by a sensitive soybean variety. Two transects were established in the soybean crop perpendicular to each spray application where visible injury ratings were taken at established distances downwind and upwind from the sprayed area. Buckets were placed over 3 soybean plants at each rating location and removed 30 minutes after application to better observe injury from secondary drift mechanisms. At 14 days after application, off-target movement from the See & Spray application did not move further than the 5-m rating location from the sprayed area, with injury ratings no higher than 1%. Off-target movement from the commercial application was observed out to the 20.1 m from the sprayed area with injury ratings as high as 33% 5 m from the sprayed area. Overall area of damaged soybean with the See & Spray application was reduced 9.5 fold compared to the commercial dicamba application. Based on this research, See & Spray technology could help reduce off-target movement of dicamba.

EVALUATION OF HERBICIDE OPTIONS FOR COVER CROP TERMINATION. W. C. Greene*[1], M. L. Flessner[2], K. B. Pittman[2], K. W. Bamber[2], L. S. Rector[2], C. W. Cahoon[3]; [1]Virginia Tech, Virginia Tech, VA, [2]Virginia Tech, Blacksburg, VA, [3]Virginia Tech, Painter, VA (271)

ABSTRACT

Cover crop use as a weed suppression tactic has been increasing as cases of herbicide resistance continue to rise. To effectively suppress weeds, high cover crop biomass is needed, which necessitates later termination timing. Delaying termination allows plants to grow larger and mature, which can make termination difficult. Studies were conducted to determine the most effective herbicide options such as 2,4-D, dicamba, halauxifen-methyl, saflufenacil, and glufosinate alone and with glyphosate or paraquat to terminate a range of cover crop species. Grass cover crop species were controlled (100%) by glyphosate and tank-mixes containing glyphosate 4 weeks after application. Overall, the legume species varied in response to the single herbicide treatments. On average, glufosinate provided the greatest control of legume cover crop species among the single active ingredients, resulting in no less than 80% control on any species with the exception of rapeseed. Legume control increased, on average, with the addition of glyphosate or paraquat. Crimson clover (*Trifolium incarnatum*L.) and hairy vetch (*Vicia villosa*Roth) were controlled better with tank-mixes containing glyphosate (79 and 87%, respectively) compared to tank-mixes with paraquat (72 and 79%, respectively.) For Austrian winter pea (*Pisum sativum*L. ssp. *sativum*var. *arvense*), there was no difference in control between the tank-mixes. Rapeseed (*Brassica napus*L.) was not adequately controlled by any treatment in this study, with 58% control observed with single active ingredient treatments and 62% control with tank-mixes. Height reduction for all cover crop species supports visible control data. For adequate termination of rapeseed, applications should be made when plants are smaller, which could negate weed suppressive benefits from this cover crop species. To ensure that growers receive all the benefits of cover crop cultivation, care should be taken to consider what is the most appropriate herbicide for the given cover crop species, as well as the appropriate timing of termination.

2,4-D AMINE AND 2,4-D BUTOXYETHYL ESTER BEHAVIOR IN EURASIAN AND HYBRID WATERMILFOIL. M. F. Ortiz*[1], M. Figueiredo[1], S. J. Nissen[1], F. E. Dayan[1], R. M. Wersal[2], W. Ratajczyk[2]; [1]Colorado State University, Fort Collins, CO, [2]Lonza, Alpharetta, GA (272)

ABSTRACT

Hybrid watermilfoil is becoming more prevalent in many lakes where Eurasian (*Myriophyllum spicatum*) and Northern watermilfoil (*M. sibiricum*) co-occur. These hybrids between Eurasian and the native Northern watermilfoil have a 30% faster growth rate and in many cases are less sensitive to 2,4-D than either parent. In order to understand why these hybrids are less sensitive to 2,4-D we investigated 2,4-D acid and 2,4-D butoxyehtyl ester (BEE) absorption, translocation, metabolism, and desorption in Eurasian and hybrid watermilfoil. The hybrid watermilfoil was from Hayden Lake, ID and is known to have reduced 2,4-D sensitivity. Herbicide absorption, translocation, and metabolism were evaluated over a 192 h time course, while herbicide desorption was evaluated over a time course of 72 h. The mathematical function that best fit these experimental data were the same for both 2,4-D formulations and both watermilfoils; however, 2,4-D BEE was more rapidly absorbed and reached a higher concentration in the plant compared to 2,4-D acid. We anticipated this result since 2,4-D BEE has a much higher log K_{ow} than 2,4-D acid. 2,4-D BEE was rapidly metabolized and by 12 HAT 100% of the absorbed 2,4-D BEE was metabolized to the free acid. The rate of 2,4-D metabolism to a primary unknown metabolite was similar for both species. Herbicide desorbed when treated plant was transferred to clean water and 2,4-D BEE desorption was higher based on the initial herbicide absorption. These data suggest that 2,4-D acid and 2,4-D BEE absorption, translocation, metabolism, and desorption do not account for reduced 2,4-D sensitivity in hybrid watermilfoil.

FLORPYRAUXIFEN-BENZYL ACTIVITY ON COMMON AQUATIC WEEDS IN LOUISIANA RICE. S. Rustom*[1], E. P. Webster[1], B. McKnight[1], D. C. Walker[1], C. Webster[2]; [1]Louisiana State University, Baton Rouge, LA, [2]Louisiana State University, Baton Rouge, AL (273)

ABSTRACT

Florpyrauxifen-benzyl Activity on Common Aquatic Weeds in Louisiana Rice
S.Y. Rustom, E.P. Webster, B.M. McKnight, D.C. Walker, L.C. Webster

Louisiana State University Agricultural Center, Baton Rouge

Florpyrauxifen-benzyl is a synthetic auxin herbicide in the arylpicolinate family introduced for use in commercial rice production by Corteva Agriscience™ in 2018. The unique binding affinity of florpyrauxifen-benzyl provides an alternative mechanism of action for postemergence broadleaf, grass, and sedge management in rice. In Louisiana rice, extended field inundation periods from water seeding or crawfish rotations can select for weeds adapted for growth in aquatic environments. In 2018, a field study was conducted at two locations at the H. Rouse Caffey Rice Research Station near Crowley, Louisiana to evaluate the response of aquatic weeds treated with titrated rates of florpyrauxifen-benzyl from 0 to 30 g ai ha^{-1}. The experimental design was a randomized complete block with four replications. Aquatic weeds were transplanted into a 91 x 91 cm galvanized ring for herbicide containment within each plot with no rice planted in the research area. Evaluations included percent control with 0 = no control and 100 = complete plant death at 14, 28, 42, and 56 days after treatment (DAT) and above ground fresh weight biomass at 56 DAT. Control and biomass data were subjected to ANOVA and means were separated using Tukey's HSD where P<.05. Nonparemetric regression was performed using PROC LOESS in SAS to characterize the effects of rate on control and biomass for each weed species. Control for broadleaf cattail (*Typha latifolia* L.), alligatorweed [*Alternanthera philoxeroides* (Mart.) Griesb.], and yellow nutsedge (*Cyperus esculentus* L.) treated with florpyrauxifen-benzyl at 25.6 g ha^{-1} was greater than 85%, similar to each weed treated with florpyrauxifen-benzyl at 30 g ha^{-1}. A similar response was observed for pickerelweed (*Pontederia cordata* L.) treated with florpyrauxifen-benzyl at 22 g ha^{-1}, and grassy arrowhead (*Sagittaria graminea* Michx.) or ducksalad [*Heteranthera limosa* (Sw.) Willd.] treated with 14.6 g ha^{-1}. Control of water primrose [*Ludwigia peploides* (Kunth.) P.H. Raven)] did not exceed 48% regardless of florpyrauxifen-benzyl rate. These data indicate reduced rates of florpyrauxifen-benzyl can be used to effectively manage broadleaf cattail, alligatorweed, yellow nutsedge, pickerelweed, grassy arrowhead, and ducksalad; however, the herbicide should be avoided when water primrose is present.

HOW DOES TEMPERATURE RISE AND *BACILLUS SP. I*NOCULATION AFFECT GERMINATION AND ESTABLISHMENT OF NATIVE AND INVASIVE SPECIES WITHIN RIPARIAN FOREST? O. Cano*[1], G. Muro-Pérez[2], J. Sánchez-Salas[3], J. Sáenz-Mata[3], E. Jurado[4], J. Flores[5]; [1]Biological Sciences Faculty - UJED, Lerdo, Mexico, [2]Biological Sciences Faculty - UJED, Gomez Palacio, Mexico, [3]Biological Sciences Faculty - UJED, Gómez Palacio, Mexico, [4]Forestry Sciences Faculty - UANL, Linares, Mexico, [5]Environmental Sciences Division - IPICYT, San Luis Potosi, Mexico (274)

ABSTRACT

By means of understanding the mechanisms of propagation and interaction between native
and invasive species within the riparian forest mediated by bacterial action and under simulated conditions of climate change, it will be poss
mortality, cypress showed no survival under interspecific competition for this case. Similarly, the presence of ragweed could inhibit the esta

RESPONSE OF SWEETPOTATO TO FLURIDONE ALONE OR IN COMBINATION WITH FLUMIOXAZIN FOLLOWED BY *S*-METOLACHLOR. S. C. Smith*, K. M. Jennings, S. Chaudhari, D. Monks; North Carolina State University, Raleigh, NC (275)

ABSTRACT

Fluridone is registered in cotton and aquatic systems, and was under a Section 18 Emergency Use Exemption label in North Carolina in 2017 for Palmer amaranth control in sweetpotato. Field studies were conducted at the Horticultural Crops Research Station in Clinton, NC in 2017 to determine the optimum herbicide combination to be used with fluridone for controlling Palmer amaranth. Treatments included fluridone at 16 or 21 oz/A PREPLANT alone or with fomesafen or flumioxazin, and flumioxazin alone. All herbicide treatments also had *S*-metolachlor applied 7 days after planting. Weedy and weed-free check treatments were included for comparison. Data collected included visual crop injury, Palmer amaranth control, and sweetpotato yield and quality. Fluridone plus flumioxazin PREPLANT followed by *S*-metolachlor provided the greatest Palmer amaranth control (88%) at 10 WAP. All fluridone treatments caused low levels (<20% at 4 WAP) of transient chlorosis. All herbicide and weed-free treatments had similar marketable yield.

MODELING FLOODING AND BURIAL EFFECTS ON THE EMERGENCE OF 5 CALIFORNIA WEEDY RICE BIOTYPES. L. B. Galvin*[1], M. B. Mesgaran[2], K. Al-Khatib[1], W. B. Brim-DeForest[3]; [1]University of California, Davis, Davis, CA, [2]University of California, Davis, CA, [3]University of California, Davis, Yuba City, CA (276)

ABSTRACT

Weedy rice (*Oryza sativa* f. *spontanea*), a common pest in the Southern United States as well as other rice growing regions of the world, has recently become a significant weed in California rice production systems. There are five conspecific weedy rice accessions in California which are difficult to differentiate phenotypically from cultivated rice. Because there are currently no registered herbicides available for weedy rice control in California, alternative management methodologies are needed for reducing its prevalence. To address this goal, an emergence experiment was conducted under controlled conditions. Treatment combinations of four flooding depths at 0, 5, 10, and 15cm as well as four burial depths, 1.25, 2.5, 5, and 10 cm, were applied in combination to the five weedy rice accessions, simply referred to as Types 1, 2 ,3 ,4, 5, as well as 'M-206' rice (medium grain, median maturity) for comparison. This experiment was conducted three times through the growing season from June through August. Each experiment lasted 21 days with emergence counted daily and water and air temperature logged hourly. Burial depth played a more significant role in decreasing emergence compared with flooding depth. All rice accessions did not emerge from burial depths deeper than 5 cm, but all varieties were able to emerge from 15cm flooding depths when buried at depths at or shallower than 2.5 cm. All rice accessions including M206 had similar emergence patterns, however, all weedy rice accessions, with the exception of one biotype, had significantly more biomass than the control after harvest. Emergence appeared to increase with increasing temperature, providing evidence for shaping future germination experiments.

PERSISTENCE OF ATRAZINE, TOPRAMEZONE AND MESOSULFURON-METHYL IN DIFFERENT NORTH CAROLINA SOIL TYPES: THE FIRST STEP IN INVESTIGATING THE POTENTIAL FOR HERBICIDE CARRYOVER DAMAGE TO SOYBEAN (*GLYCINE MAX*) CROP. S. S. Ramanathan*[1], T. Gannon[1], A.

Locke[2], W. Everman[1]; [1]North Carolina State University, Raleigh, NC, [2]USDA-ARS and North Carolina State University, Raleigh, NC (277)

ABSTRACT

Persistence of three herbicides, atrazine, mesosulfuron-methyl and topramezone, was determined in five North Carolina soils varying in textures by performing laboratory incubation studies. Unique soil samples weighing 25g each were treated with atrazine (2.24 kg ai ha^{-1}), mesosulfuron-methyl (0.01 kg ai ha^{-1}) or topramezone (0.02 kg ai ha^{-1}) solutions prepared at the label prescribed 1x application rate. Treated and nontreated samples were incubated at 21°C under aerobic conditions and arranged in a randomized complete block design with four replicates. Soil samples were maintained at field capacity and harvested at regular time intervals which were constructed based on published half-life values. Atrazine samples were collected 0, 4, 8, 15, 30, 45, 60 and 90 days after treatment (DAT) and meosulfuron-methyl and topramezone samples were collected 0, 3, 6, 11, 23, 34, 45 and 68 DAT and stored at -18°C until extraction. Herbicide residues were extracted using acetone or dichloromethane and analyzed using high performance liquid chromatography coupled with a diode array detector with a limit of detection of 0.0250 ppm and limit of quantification of 0.0125 ppm. Half-lives were calculated using linear regression models. The incubation study for mesosulfuron-methyl was repeated at 7°C to compare the effect of temperature on its persistence since this herbicide is applied primarily during the winter months. The soil half-lives of atrazine and topramezone showed differences across soil types with the shortest persistence in 'Candor' sand (37.7 and 14.9 days, respectively) and longest in 'Portsmouth' sandy loam (73.3 and 19.1 days, respectively). Differences were also detected in the half-life values of mesosulfuron-methyl across soils with greater persistence at lower evaluated temperature. Further research is needed to substantiate the effect of soil pH on the variation of mesosulfuron-methyl persistence in the presented data compared to values reported in the literature. Collectively, the data suggest herbicide persistence is influenced by the combination of soil and herbicide physicochemical properties. Also, region-specific evaluation of herbicide persistence is important primarily because of variations in soil textures and correlations between pesticide adsorption and organic carbon and clay contents in soils, which will also be determined for this study. Differentiation of herbicide persistence across various soils is a vital step in identifying the potential carryover concentrations of the herbicides and the extent of damage they can cause to soybean (*Glycine max*) physiology in these soils.

A MECHANISTIC FRAMEWORK TO EXPLAIN YIELD LOSS IN CORN (*ZEA MAYS* L.) CAUSED BY EARLY SEASON STRESS. H. Gonzalez*, E. A. Lee, L. Lukens, C. J. Swanton; University of Guelph, Guelph, ON (278)

ABSTRACT

Physiological stress caused by early season weed competition, drought, or intraspecific competition can result in rapid yield loss in corn (Zea mays L.). The mechanism by which these stresses cause yield loss is not well known. It was hypothesized that if early season physiological stress caused by abiotic or biotic variables reduces yield then the mechanism by which this occurred was the result of a reduction in kernel set, and a subsequent increase in anthesis-to-silking interval. Field trials were conducted in 2012 and 2013 at two locations (Arkell and Elora Research Stations). Treatments included an enriched far red ratio, drought and intraspecific competition (15 plants/m^2). Early season stress negatively impacted kernel set and flowering dynamics. The reduction in kernel set was driven primarily by reductions in plant growth rates at silking. A delay in days to anthesis and silking was also observed because of a reduction plant dry matter accumulation during the early vegetative phase of corn growth. This research provides a mechanistic explanation for the rapid loss in yield that occurs in corn as a result of early season stress caused by abiotic and biotic variables.

ESTIMATING STANDING BIOMASS OF AN INVASIVE PLANT USING SUAS. A. Howell*[1], R. Richardson[2]; [1]North Carolina State University, Sanford, NC, [2]North Carolina State University, Raleigh, NC (279)

ABSTRACT

With the advent of small unmanned aircraft systems (sUAS), research scientists and plant managers are capable of obtaining unique, fast, and low-cost quantitative data which delivers many repeatable survey options. Benefits of autonomous sUAS platforms include minimal training, reduced human safety concerns, and creation of graphic outputs which may be readily viewed by any stakeholder who was not actively involved in the survey or management activity. Research conducted in the Wellington Region, New Zealand was used to evaluate sUAS technologies to map and estimate standing biomass of Manchurian Wild Rice (*Zizania latifolia*), an exotic semi-aquatic grass which can promote flooding, and displacement of native flora and fauna. The goal of this research was to improve the speed and resolution of current survey strategies used to assess *Z. latifolia* among a lowland pasture site using unmanned systems. Image collection and data processing was conducted in a manner which provided a theoretic biomass estimation of remaining *Z. latifolia* following seasonal growth and herbicide applications. Post-processing methods and theories discussed attempt to identify and quantify *Z. latifolia* biomass using supervised imaging analysis, plant height modeling, and biomass collected *in situ*. The use of unmanned systems to map, monitor, and manage *Z. latifolia* is encouraged for future applications.

EVALUATION OF SEED DORMANCY IN RYEGRASS (*LOLIUM* SPP.) ACCESSIONS COLLECTED FROM TEXAS BLACKLANDS. A. Maity*[1], S. Abugho[1], V. Singh[1], N. Subramanian[1], G. R. Smith[2], M. V. Bagavathiannan[1]; [1]Texas A&M University, College Station, TX, [2]Texas A&M University, Overton, TX (280)

ABSTRACT

Ryegrass (*Lolium* spp.) is considered a major weed in wheat production systems worldwide. It is a unique species, which exhibits adaptability to a wide range of environmental conditions due to its high genetic diversity. In Texas, ryegrass is the most dominant weed in wheat production in the Blacklands, yet little is known on the diversity and adaptive characteristics of this species in this region. Ryegrass accessions were collected randomly in wheat production fields across the Texas Blacklands region and were assessed for seed dormancy at three-month intervals for up to nine months. Seed samples showed wide variability in dormancy levels ranging from 27 to 97% across the accessions at three months after harvest, but the variability reduced at six (12 – 72%) and nine months (16 – 62%) after harvest. Mean seed dormancy level was 58.13±2.08, 39.72±2.00, and 33.22±1.55, respectively after three, six and nine months of harvest. Results provide a comprehensive understanding of seed dormancy in ryegrass accessions from Texas. Further research is underway to determine herbicide resistance status of these accessions and potential association between herbicide resistance and other functional traits. (muthu@tamu.edu)

INTERACTION OF LACTOFEN WITH GLYPHOSATE OR GLUFOSINATE FOR WEED CONTROL AS AFFECTED BY ADJUVANTS AND DROPLET SIZE. J. Gizotti de Moraes*, C. Chiaranda Rodrigues, B. Vukoja, G. Kruger; University of Nebraska-Lincoln, North Platte, NE (281)

ABSTRACT

Glyphosate or glufosinate have been extensively tank-mixed with PPO-inhibiting herbicides applied to genetically modified crops to broaden weed control while managing herbicide-resistant weeds. More information about how these herbicides and adjuvants interact when applied in combination as well as the optimal droplet size for weed control is needed. Therefore, the objective of this study was to determine the interaction of lactofen with glyphosate or glufosinate for weed control as affected by

adjuvants and nozzle selection. Four plant species were used: kochia (*Kochia scoparia* (L.) Schrad.), horseweed (*Conyza canadensis* (L.) Cronq.), common lambsquarters (*Chenopodium album* L.), and grain sorghum (*Sorghum bicolor* (L.) Moench ssp. *Bicolor*). Treatments were arranged in a 10 x 2 factorial consisting of ten spray solutions and two nozzle types (XR11004 and TTI11004). Spray treatments consisted of postemergence applications of glyphosate at 630 g ae ha^{-1}, glufosinate at 212 g ai ha^{-1}, lactofen at 110 g ai ha^{-1}, or lactofen at 110 g ai ha^{-1} with crop oil concentrate (COC) at 1% v v^{-1}, non-ionic surfactant (NIS) at 0.25% v v^{-1}, methylated seed oil (MSO) at 1% v v^{-1}, or a drift reducing agent (DRA) at 0.5% v v^{-1}, and either glyphosate or glufosinate with lactofen in combination with each of the adjuvants aforementioned. All applications were performed at 276 kPa and 9 kph to deliver 187 L ha^{-1} using a three-nozzle laboratory track sprayer. Droplet size spectra were also recorded using a laser diffraction system. Data were subjected to ANOVA and means were separated using Fisher's Protected LSD test with the Tukey adjustment. Although the interaction between nozzle and solution were all significant for droplet size spectra, the nozzle effect had a greater impact when using glufosinate. The XR nozzle had the highest level of weed control when using glufosinate. Increased percent of fine droplets (<150 μm) produced was observed by the interaction between nozzle and solution, particularly when glyphosate was used alone in combination with the XR nozzle. Finer droplets may be required when using mixtures containing glufosinate herbicide applied to horseweed and common lambsquarters whereas kochia and grain sorghum, as well as mixtures containing glyphosate, coarser droplets would be recommended to minimize drift potential of the spray solution without any cost of reduced efficacy. Optimum control is both adjuvant and weed species specific.

DESCRIBING PHENOLOGY PATTERNS OF DIFFERENT NATURAL COHORTS OF SICKLEPOD (*SENNA OBTUSIFOLIA* (L.) IRWIN & BARNEBY) USING SIGMOIDAL MODELS. T. A. Reinhardt Piskackova*, K. M. Jennings, R. Richardson, C. Reberg-Horton, R. Leon; North Carolina State University, Raleigh, NC (282)

ABSTRACT

Weed emergence timing can often affect the interactions between crop and weeds; however, empirical models have seldom been used to predict weed phenology. Three cohorts of emerging sicklepod phenology patterns were studied in Kinston and Rocky Mount, NC. At intervals, sampled individuals of the population of sicklepod were categorized as 1) vegetative under 10cm, 2) vegetative above 10 cm, 3) flowering, 4) seed pods forming, 5) seed maturity, 6) plant senescence. These proportions were modeled over chronological, thermal, and hydrothermal time with the purpose to create a predictive model for sicklepod growth. The results indicated that thermal and hydrothermal time have decreasing predictive power as phenology progresses from seedling emergence to reproductive stages.

EVALUATION OF SOYBEAN TOLERANCE TO OFF-TARGET LOYANT™ (FLORPYRAUXIFEN-BENZYL) DEPOSITION. D. C. Walker*[1], E. P. Webster[1], D. O. Stephenson[2], B. McKnight[1], S. Rustom[1], C. Webster[3]; [1]Louisiana State University, Baton Rouge, LA, [2]Louisiana State University AgCenter, Alexandria, LA, [3]Louisiana State University, Baton Rouge, AL (283)

ABSTRACT

Evaluation of Soybean Tolerance to Off-target Loyant™ (florpyrauxifen-benzyl) Deposition. D.C. Walker*, E.P. Webster, D.O. Stephenson, B.M. McKnight, S.Y. Rustom, M.J. Osterholt and L.C. Webster. Louisiana State University.

ABSTRACT

In 2018, Corteva Agriscience released a new postemergence herbicide florpyrauxifen-benzyl, sold under the trade name Loyant, which allows growers to control broadleaf, grass and sedge weeds in rice. This product is a group 4 synthetic auxin with a unique site of action that is different than other group 4 herbicides. With the introduction of this herbicide also came complaints of off-target movement, similar to that of other auxin herbicides. Off-target deposition of this herbicide has proven to be injurious to susceptible vegetation including soybean. Therefore, soybean tolerance to this product must be evaluated.

The objectives of this study were: 1) to determine the effect of florpyrauxifen-benzyl application timing and deposition rate on soybean growth and yield; 2) to determine if there is differential tolerance between dicamba-tolerant (DT) and non-DT soybean. Trials were conducted in 2018 in Alexandria, Crowley and Iowa, LA with DT soybean at one location and non-DT soybean at the other two locations. Soybean were treated with a single application of florpyrauxifen-benzyl at either the V3 to V4 or R1 to R2 growth stage with 7.34, 1.84, 0.46, 0.11, or 0.03 g ai ha^{-1} which is equivalent to 1/4X, 1/16X, 1/64X, 1/256X and 1024X of the full labeled rate of florpyrauxifen-benzyl at 29.44 g ai ha^{-1}. Also, two rates of dicamba in the Xtendimax® formulation at 7.09 and 0.24 g ae ha^{-1} which is equivalent to 1/32X and 1/1000X of the full labeled rate of dicamba at 558 g ae ha^{-1} were included as a comparison.

Results indicate that florpyrauxifen-benzyl deposition on soybean at the R1 to R2 application timing will result in greater yield reduction compared with soybean treated at the V3 to V4 application timing. Furthermore, all florpyrauxifen-benzyl treatments resulted in a yield reduction with 1/4X causing a 100% yield loss and 1/1024X causing 15% yield reduction.

IMPROVING SELECTIVITY OF PHYSICAL WEED CONTROL IN WINTER SQUASH: CULTIVATION TOLERANT VARIETIES AND TRAITS. M. M. Benzle*, D. C. Brainard; Michigan State University, East Lansing, MI (284)

ABSTRACT

Physical weed control (PWC) is an important tool for managing weeds in organically produced cucurbit crops, but low selectivity at early growth stages limits successful adoption. One approach to improve selectivity of PWC is to use varieties that are tolerant to forces applied by PWC tools. Field experiments were carried out during the 2017 and 2018 growing seasons in southwest Michigan to test whether commercially available *Cucurbita pepo* (acorn and delicata squash) varieties varied in their tolerance to mechanical disturbance from flextine and finger weeders, and to identify traits associated with that tolerance. For each tool, separate experiments were conducted in a split plot design, with PWC (handweeding vs flextine or finger weeding) as the main plot factor, and *C. pepo* variety (Taybelle, Jester, Delicata, Honey Bear, Sugarbush and Tuffy) as the subplot factor. Pre- and post- counts of weeds and crops were used to calculate the efficacy and selectivity of the tools. In separate greenhouse and growth chamber studies, seedling traits including time to emergence, root:shoot ratio (RSR), root tip number, projected area, and anchorage force were evaluated to gain insight into variation in traits associated with tolerance to PWC. Varietal differences in tolerance to both flextine cultivation and finger weeding were evident in several site-years, although results were variable and inconsistent. The most tolerant varieties (e.g. 'Taybelle') generally had greater size at the time of cultivation, greater partitioning to root tissue (higher RSR) and greater anchorage force, compared to the most susceptible cultivars (e.g. 'Delicata'). These results suggest that growers can improve weed management through use of commercially available varieties that are tolerant to PWC tools, and that plant breeders may improve this tolerance through selection for PWC tolerant traits.

SEED PRODUCTION POTENTIAL AMONG DIVERSE CYTOPLASMIC MALE STERILE *SORGHUM BICOLOR* GENOTYPES FOLLOWING NATURAL POLLINATION WITH *S. HALEPENSE*. C. Sias*, G. Hodnett, W. Rooney, M. V. Bagavathiannan; Texas A&M University, College Station, TX (285)

ABSTRACT

The potential for gene flow between cultivated species and their weedy relatives poses agronomic and environmental concerns, particularly when there are opportunities for the transfer of specific adaptive traits or agronomic traits such as herbicide resistance into the weedy forms. Knowing the frequency of these genetic exchanges and their characteristics in agricultural production systems is of utmost importance for understanding their environmental and agronomic implications. One of the most widely cultivated crops in Texas, Sorghum bicolor, is a prime example of a crop that has a weedy relative, S. halepense, capable of exchanging genetic information. Previous findings have shown that the resulting triploid progenies typically collapse and only few of them develop into mature seed, whereas the tetraploids often turn into fully developed seeds. The objective of this experiment was to determine the frequency of seed-set across 12 different sorghum genetic backgrounds and 3 male sterility types after pollination with johnsongrass, which is an indication of the differences in hybridization potential among the different sorghum lines. Preliminary results show wide variability in seed-set among the different sorghum genetic backgrounds. Results suggest that hybridization potential between sorghum and johnsongrass can be reduced by selection of appropriate sorghum genetic backgrounds.

POLLINATOR USE OF GROWING SEASON COVER CROPS IN AN AGROECOSYSTEM. C. J. Bryan*, S. Sipes, L. Kassim, D. Gibson, D. Scott, K. L. Gage; Southern Illinois University, Carbondale, IL (286)

ABSTRACT

Pollinators are essential to sustain natural and managed ecosystems. They are vital for food production and their declines have been linked, in part, to a rise in intensive agricultural practices. There is a recognized need among numerous stakeholders to build sustainability into the management of agroecosystems to protect biotic and abiotic resources. The use of cover crops is gaining interest among agricultural producers and may have the potential to provide floral resources to pollinators and suppress problematic driver weeds. The overall objective of this study was to quantify the effects of cover crops on plant and pollinator biodiversity within agricultural systems. This study aimed to evaluate the roles growing-season cover crop treatments play in supporting pollinator diversity and weed suppression benefits in a conventionally-managed system on Crab Orchard National Wildlife Refuge; and provide the basis of recommendations for sustainable weed suppression tactics and for enhancing the quality of pollinator habitat within a fallow growing-season agricultural system. The study was designed to test for weed suppression efficacy and weed community shifts in response to five cover crop treatments and a control between and within fields, following a soybean rotation. Weed species and percent cover were measured in 25 fields, over the course of three survey periods (early April, mid-June, and late July) in 2016 and 2017. Bee sampling and floral abundance surveys occurred approximately every three weeks from mid-April to end of August 2017. Bee sampling consisted of both pan traps and netting techniques. Mixed models with blocking by survey round showed a significant treatment effect on diversity (eH′), evenness (J′), and richness (S) of agricultural weeds across all survey rounds. The no-cover crop treatment had a higher median richness (S) value compared to all other treatments and the control. The response of driver weed cover by treatment resulted in no significant differences among treatments, suggesting all treatments had similar levels of driver weeds present. Our results suggest that weed communities are not impacted by the presence of a cover crop. However, univariate statistics assessing diversity suggest that cover treatments are influencing diversity metrics. Sampling efforts across all cover treatments combined yielded the collection of 5,898 bee specimens. This collection represents a total of 5 families, 28 genera, and 106 species. Cover crop treatment effect on log bee abundance across all survey rounds of the experiment was significant. Bee diversity (eH′) showed a weak, but positive response to floral diversity (eH′). Treatment effect on bee richness (S) across all survey rounds of the experiment was significant. Floral abundance was not significantly different between cover treatments or by survey round. However, there was a survey round effect and treatment effect on floral richness (S). Many of the smaller bee species recorded during this study were collected off agricultural weeds, while larger bodied bees, such as bumble bees (*Bombus*), had a strong affiliation to the *Trifolium* species present in the cover crop treatments. Our bee floral associations suggest that both agricultural weed communities and supplemental cover crop plantings are important floral resources for the Refuge bee populations. Based on our results, the two treatments that supported the highest bee abundance (N) and richness (S), suggests the sustained floral resource availability throughout the growing season, especially into the later months are important factors for supporting diverse and abundant bee populations. Our findings support the incorporation of cover crops into rest year rotations, particularly growing-season fallow rotations, to support bee populations in agroecosystems. Our research also supports the idea that agricultural weeds are important for supporting native bee populations. Although the use of growing season cover crops is not typical in the geography of southern Illinois, the value of providing floral resources to pollinators throughout the growing season is highlighted by this work.

BROWNTOP MILLET (*UROCHLOA RAMOSA*) AND BROADLEAF SIGNALGRASS (*UROCHLOA* PLATYPHYLLA) COMPETITION EFFECTS ON GROWTH AND YIELD OF PEANUT (*ARACHIS HYPOGAEA*) MANAGED WITH PROHEXADIONE CALCIUM. Z. R. Treadway*[1], J. Ferguson[1], J. T. Irby[1], B. Zurweller[2], J. Gore[3]; [1]Mississippi State University, Mississippi State, MS, [2]Mississippi State University, Starkville, MS, [3]Mississippi State University, Stoneville, MS (287)

ABSTRACT

Browntop Millet (*Urochloa ramosa*) and Broadleaf Signalgrass (*Urochloa* platyphylla) Competition Effects on Growth and Yield of Peanut (*Arachis hypogaea*) Managed with Prohexadione Calcium

Zachary R. Treadway, J. Connor Ferguson, Jon T. Irby, Brendan Zurweller, Jeffery Gore

The use of prohexadione calcium growth regulator on peanut *(Arachis hypogaea)* has become a common practice among producers. The chemical is known to reduce internode elongation, which leads to rows that are easily differentiated from one another for greater pod production which is often lost due to the excessive vegetative growth of runner peanuts in Mississippi. Studies have also concluded that peanut plants that have been subjected to the two labeled applications of prohexadione calcium show increased yields at time of harvest and also exhibit a decrease in the amount of pods shed from the plant during growth and digging.

With the increasing dependence on prohexadione calcium, a question was posed about the efficacy of the growth regulator when applied to peanut plants under stressful conditions. An experiment was conducted at Mississippi State University in which a field of Georgia-06G peanuts were subjected to various factors to produce a stressful environment. Treatment plots included an herbicide damaged crop and a crop suffering from leaf spot. Treatment plots were mirrored, in that each treatment was broken into sub-treatments. Each treatment plot had a sub-treatment plot that was constantly under weed pressure from browntop millet *(Urochloa ramosa)*, and broafleaf signalgrass *(Urochloa platyphylla)*, and a sub-treatment that was subject to weed control.

Plots were harvested, and the results proved that a weed free environment lends itself to a higher peanut yield across treatment compared to one with heavy *Urochloa* spp. pressure. The highest yield was 6,173 kg ha^{-1} without any environmental or weed pressure whereas the yields were only 1,522 kg ha^{-1} when plants were suffering from

leaf spot with heavy *Urochloa* spp. weed pressure.

Results concluded that weed pressure and stress level both have an influence on the efficacy of prohexadione calcium and therefore have an effect on yield. The only way to insure an economical and effective application of prohexadione calcium is to apply on weed free and healthy peanuts.

OPTIMIZING COVER CROP AND HERBICIDE INPUTS FOR WEED MANAGEMENT IN NO-TILL CORN AND SOYBEAN. J. M. Bunchek*[1], J. M. Wallace[2], W. S. Curran[3], D. Mortensen[2], M. J. VanGessel[4], B. A. Scott[4]; [1]Penn State University, State College, PA, [2]Penn State University, University Park, PA, [3]Penn State University, Bozeman, MT, [4]University of Delaware, Georgetown, DE (288)

ABSTRACT

Widespread adoption of genetically-engineered, herbicide-resistant (HR) crops has simplified crop rotation diversity and the use of single-tactic, herbicide-based weed management programs. These practices have contributed to the increase in glyphosate-resistant species like horseweed [*Erigeron canadensis* (L.)] and pigweeds (*Amaranthus spp.*), which threaten soil health gains in conservation tillage systems. Cost-effective integrated weed management (IWM) programs that implement both ecological- and herbicide-based tactics are needed in no-till annual grain systems to improve management of HR weeds, reduce selection pressure on current herbicide technologies, and preserve grain crop yield. We established field experiments in corn and soybean at two Mid-Atlantic locations (PA and DE) to evaluate the integration of high-residue cover crops and various herbicide programs that differed in inputs. Cover crop treatments in corn included a no cover control, cereal rye (*Secale cereal* L.) "Aroostook" + crimson clover (*Trifolium incarnatum* L.) "Dixie" mixture, and cereal rye + hairy vetch (*Vicia villosa* Roth) "Auburn early cover" mixture. Cover trop treatments in soybean included a no cover control, cereal rye, and cereal rye + hairy vetch mixture. Herbicide programs included a spring pre-plant burndown herbicide application (PP) program, PP + PRE-residual program, PP + POST-emergent program, and standard PP + PRE + POST program. In addition to assessing the productivity of the cover crop treatments, we compared the weed control efficacy of the standard herbicide program with the reduced-input, lower cost programs. Further, as cover crop ground cover increased, a greater portion of the PP was intercepted and refrained from reaching the soil surface. In soybean, cereal rye intercepted 31% of the PP, yet weed biomass at the time of PP application was 95% lower than the no cover control. Likewise, cereal rye + hairy vetch intercepted 54% of the PP application and had 93% lower weed biomass than the no cover control. The cover crops preemptively controlled weeds at PP application, reducing the HR selection pressure. Our studies concluded that IWM programs that optimize ecological- and herbicide-based tactics can manage weed pressure and maintain conservation tillage as an option for Mid-Atlantic growers.

ITALIAN RYEGRASS (*LOLIUM MULTIFLORUM*) TIMING OF REMOVAL EFFECTS ON CORN (*ZEA MAYS* L.) IN MISSISSIPPI. M. T. Wesley*[1], J. A. Bond[2], D. B. Reynolds[3], E. J. Larson[4], J. Ferguson[3]; [1]Mississippi State University, MS State, MS, [2]Delta Research and Extension Center, Stoneville, MS, [3]Mississippi State University, Mississippi State, MS, [4]Mississippi State University, Starkville, MS (289)

ABSTRACT

Michael Wesley

Timing of Removal Abstract 2019

A field study was conducted to determine the effects of Italian ryegrass (*Lolium perenne ssp. multiflorum*) removal timing on corn (*Zea mays* L.) productivity in Mississippi. The study was conducted at the Black Belt Research Station in Brooksville, Mississippi and included 10 different timings: 90 days before planting (DBP), 69, 56, 44, 30, 22, 15, 8, at planting, and 34 days after planting, arranged in a Randomized Complete Block design with four replications. Treatment timings were the events where Italian ryegrass was sprayed at different dates relative to corn planting. The study also included an untreated check and a weed-free check. The earliest treatment was sprayed on January 5th, 2018. The latest treatment was sprayed May 7th, 2018. *S*-metolachlor plus atrazine plus mesotrione plus bicylopyrone (Acuron) at 1,952 g ai ha^{-1} and paraquat (Gramoxone SL 2.0) at 2,270 g ai ha^{-1} were used in this study. Paraquat was not included in the tank mixture after corn emerged. All treatments were applied using a four-nozzle boom sprayer at 4.3 km h^{-1}, a carrier volume of 140 L ha^{-1}, and a pressure of 276 kPa. Plots measured three by nine meters, and DeKalb 70-27 hybrid seed corn was planted on bedded, 97 cm spaced rows at 69,200 seeds ha^{-1} on April 5th, 2018. Corn development was assessed throughout the growing season by obtaining plant height measurements and leaf chlorophyll readings. Corn was harvested on August 6th, 2018, and yield was recorded and analyzed. The 90 DBP treatment resulted in the highest average corn yield of 8,970 kg ha^{-1}, while the at planting treatment yielded an average of 7,165 kg ha^{-1}, resulting in an average daily yield loss of 20 kg ha^{-1} during this time period. This data highlights the effects of Italian ryegrass removal timing on corn productivity in Mississippi.

PESTICIDE PHYTOREMEDIATION POTENTIAL OF SOUTHEASTERN US TERRESTRIAL PLANTS: *IRIS VERSICOLOR, PANICUM VIRGATUM, AND ANDROPOGON VIRGINICUS*. T. Gannon[1], F. Yelverton[1], A. M. McKnight*[2]; [1]North Carolina State University, Raleigh, NC, [2]North Carolina State University, Cary, NC (290)

ABSTRACT

Previous research has shown plant-pollutant bioremoval capacity may differ across species and/or pesticides. Phytoremediation of pesticides has been minimally investigated with plant species adapted to environmental conditions common to the southeast United States. Therefore, research is needed to expand upon current knowledge to identify plant species best suited to mitigate pesticide off-target transport for selection when establishing and/or renovating riparian buffers or stormwater wetland areas in urban and rural settings. To address this knowledge gap, greenhouse research was conducted evaluating atrazine (herbicide), azoxystrobin (fungicide) and imidacloprid (insecticide) bioremoval capacity of three terrestrial plant species [switchgrass (*Panicum virgatum*), blueflag iris (*Iris versicolor),* and broomsedge (*Andropogon virginicus*)]. These plant species were chosen based on prior trace element phytoremediation studies and the plants' tolerance to commonly used herbicides. Plants were established in unique containers (506.7 cm^2) consisting of a Candor sand (92, 4, 4% sand, silt, and clay, respectively) and treated with atrazine (2 kg ai ha^{-1}), azoxystrobin (0.5445 kg ai ha^{-1}), or imidacloprid (0.4 kg ai ha^{-1}). At 28, 56 or 112 days after treatment (DAT) unique plants were destructively harvested and sectioned into above- and below-soil surface portions for subsequent residue analysis. Additionally, four soil cores were collected form each container to a depth of 7.5 cm and segmented into 0 to 2.5, 2.5 to 5.0 and 5.0 to 7.5 cm soil depths for residue analysis. Results suggest switchgrass, blueflag iris, and broomsedge continuously remediate all

three pesticides through 112 DAT. Azoxystrobin was found to be remediated at a higher rate than atrazine or imidacloprid. Information from this research will aid in the construction of a mitigation plan for urban and rural landscapers to minimize the possible risk of off-target pesticide movement.

UTILIZING GEOSPATIAL TECHNOLOGY TO ASSESS OFF-TARGET DICAMBA INJURY AND YIELD LOSS IN MISSOURI SOYBEAN FIELDS. B. R. Dintelmann*[1], S. T. Farrell[2], K. Shannon[2], M. Bish[2], K. Bradley[2]; [1]University of Missouri, Belleville, IL, [2]University of Missouri, Columbia, MO (291)

ABSTRACT

Off-target movement of dicamba was estimated to occur on greater than 200,000 hectares of non-dicamba tolerant (DT) soybean in Missouri from 2016 through 2018. Over 50 years of research results indicate that soybean yield loss depends primarily on dose and growth stage at the time of exposure. However in field settings, practitioners are unaware of the specific dose that contacts non-DT soybean thus making it difficult to predict yield loss. The objective of this research was to determine if late-season dicamba injury evaluations can be used to predict yield loss on a field-scale level after off-target movement of dicamba has occurred. From 2016 through 2018, ten separate non-DT soybean fields were assessed for dicamba injury using the scale set forth by Behrens and Lueschen (1979). All fields assessed exhibited signs of particle drift and had dicamba injury symptoms in the upper trifoliates at the R6 stage of growth. Sample locations were established within each field using a center grid format at 25 m spacing's. Handheld GPS units were used to navigate to the pre-determined sample locations and to record the visual injury ratings when soybeans were in the R6-R7 stage of growth. Site-specific yield information was then obtained through combine yield monitors. Sampling points were overlaid with yield maps using Ag Leader SMS Advanced software. Soybean yield and visual injury ratings at each sample location were collected and compared in SAS using the GLM procedure, and means were separated using Fisher's Protected LSD at the 0.05 level of significance. Preliminary results from ten fields indicates that visual injury assessments of less than 20% at the R6-R7 stage of growth did not result in significant yield loss. However, a 6% yield loss was observed when injury ranged from 20 to 40% compared to areas where no injury was observed. When injury ranged from 40 to 60%, a 22% yield loss was observed compared to areas of the fields that were uninjured. Additionally, when injury ranged from 60 to 80%, a 44% yield loss was observed. Results from this research will help farmers and agriculture professionals to better visualize and understand the effects that late season off-target movement of dicamba can have on soybean yield on a field-scale level.

SURFACE AND LIVING MULCHES FOR STRIP-TILLED VEGETABLE PRODUCTION. J. J. Puka-Beals*[1], G. G. Gramig[2]; [1]North Dakota State University, Fargo, ND, [2]NORTH DAKOTA STATE UNIVERSITY, Fargo, ND (292)

ABSTRACT

Biodegradable mulches (BM) provide weed control without soil disturbance, herbicide usage or disposal issues associated with plastic mulches, yet BM adoption remains limited. Strip tilling into living mulches could help integrate annual crop production with perennial cover crops. Combining both approaches may be relevant to vegetable producers seeking to adopt organic growing practices. Weed and crop yield responses to three living mulch species [perennial ryegrass (*Lolium perenne*), white clover (*Trifolium repens*) and red clover (*Trifolium pratense*)] and two surface applied mulches were assessed in North Dakota during 2018. The surface mulch treatments were 1) a 50:50 mixture of hemp hurd and composted cow manure and 2) a 'hydromulch' application of shredded newspaper and water, both applied to a 23 cm wide in-row area. Carrot (*Daucus carota*) provided crop emergence and yield response. Results indicated that surface mulches were associated with decreased weed density and biomass compared to a no surface mulch control. Compost blanket was associated with the least weed density, but hydromulch was associated with the least total weed biomass. Lowest average carrot weight was associated with no surface mulch. Results suggest that in-row surface mulches effectively suppressed weeds in strip tillage living mulch systems. Living mulch species did not affect weed count or biomass within the in-row area.

INVESTIGATIONS OF THE EFFECTS OF SOIL PH ON THE VOLATILITY OF DICAMBA FORMULATIONS. E. G. Oseland*, M. Bish, K. Bradley; University of Missouri, Columbia, MO (293)

ABSTRACT

An evaluation of application parameters surrounding dicamba applications has suggested low soil pH may increase the volatility potential of dicamba formulations. Two identical field experiments were conducted in Columbia, Missouri in 2018 to determine if low soil pH increases the volatility of various dicamba formulations. The experiments were designed as a factorial in a randomized complete block. Non-dicamba tolerant soybeans were planted and plastic low-tunnels were utilized to cover two rows of soybeans for a length of six m in each plot. Soil pH was adjusted using aluminum sulfate and hydrolyzed lime resulting in soil pH values of 4.3, 5.5, 6.8, 7.7, and 8.3. Applications of dicamba were applied to greenhouse flats filled with 4.5 kg of pH-adjusted soil. Applications were made at a location geographically separate from the field trial and flats were transported by open vehicle to the field where they were placed in the center of each low tunnel between the soybean rows. Dicamba formulations used in the experiment included the diglycolamine (DGA; Clarity), N,N-Bis-(3-Aminopropyl) Methylamine (BAPMA; Engenia), diglycolamine with Vapor Grip (DGA with VaporGrip; Xtendimax), and choline salt (experimental Corteva formulation). Each flat was treated with 1.12 kg ae ha^{-1} of dicamba. A non-treated control was included for each soil pH. At 72 hours after trial establishment, the experiment was terminated and soil and tunnels were removed from the field site. At 14 days after trial termination, visual soybean injury estimates were determined using the scale previously established by Behrens and Lueschen (1979). Data were analyzed using the PROC GLIMMIX procedure in SAS. In both experiments, soybean injury as a result of dicamba vapor movement increased in severity as soil pH levels decreased. Treatments including dicamba DGA with VaporGrip and the BAPMA formulations damaged soybean at similar levels as the DGA dicamba formulation when the soil pH was 4.3 and 5.3. The DGA with VaporGrip and BAPMA formulations also resulted in higher overall soybean injury when compared to the choline salt across all soil pH treatments. The choline salt and non-treated control resulted in similar levels of soybean injury at soil pH levels of 6.8, 7.7, and 8.3. The results of these experiments suggest that acidic soil pH conditions may contribute to the potential for an application of dicamba to move off-target. Further examination of the effect soil pH has on dicamba volatility and validation of the results of these field studies will take place in 2019 in a controlled environment.

WEED SUPPRESSION AND LIGHT PENETRATION IN STANDING AND ROLLED CEREAL RYE AND WHEAT COVER CROP RESIDUE. L. S. Rector*, M. L. Flessner, D. McCall, W. Thomason; Virginia Tech, Blacksburg, VA (294)

ABSTRACT

Weed Suppression and Light Penetration in Standing and Rolled Cereal Rye and Wheat Cover Crop Residue. L.S. Rector, M.L. Flessner, D. McCall, W. Thomason; Virginia Tech, Blacksburg, Virginia.

Higher cover crop biomass is correlated with greater weed control, especially of some smaller seeded weeds that require light for germination. Cereal rye (*Secale cereale*) tends to provide the greatest weed control among cover crop species, but farmers are more likely to use wheat (*Triticum aestivum*) because wheat is typically less expensive. Cover crop residue treatment (left standing or rolled) may also influence weed control, but little is known in this regard. Therefore, research was conducted to assess the relationship between cover crop biomass, weed control, light penetration, and termination method.

Studies were conducted in Blacksburg and Shawsville, VA utilizing a factorial design with 4 replications. Factors consisted of cover crop species (wheat or cereal rye), biomass rate (none, low, medium, and high), and termination method (glyphosate at 1.5 kg ai ha^{-1} or glyphosate + a roller crimper). Cover crops were planted with a 1.5 m wide drill on September 15th for the high biomass at a seeding rate of 112 kg ha^{-1} for cereal rye and 134 kg ha^{-1} for wheat, October 15th for the medium biomass at a seeding rate of 84 kg ha^{-1} for cereal rye and 95 kg ha^{-1} for wheat, and November 15th for the lowest biomass at a seeding rate of 56 kg ha^{-1} for cereal rye and wheat. Cover crops were terminated on April 27th with glyphosate and then either left standing or rolled. Data collected consisted of cover crop biomass, visible weed control, soil moisture and temperature, and light penetration. Cover crop biomass was collected at cover crop termination. Visible weed control was recorded once per week for 4 weeks starting 2 weeks after cover crop termination (WAT) on a 0 (no control) to 100 (complete control) scale. Soil moisture and temperature data were taken in the top 5 cm of the soil. Soil temperature was obtained using a soil thermometer. Light penetration readings were taken using a meter long light bar that collected photosynthetically active radiation penetrating the cover crop residue. Soil moisture, soil temperature, and light penetration readings were taken twice a week at each location starting April 16th and ending on May 31st. Pitted morningglory (*Ipomoea lacunose*) was rated for control at Blacksburg, and common cocklebur (*Xanthium strumarium*) was rated for control at Shawsville. Data was analyzed using JMP Pro 14. Weed control, light penetration, soil temperature, and soil moisture data were subject to ANOVA and a means separation using Fishers Protected $LSD_{(\alpha=0.05)}$.

At the September 15th planting date, rolled cereal rye residue resulted in lower light penetration (180 umol s^{-1} m^{-2}) compared to standing cereal rye residue (312 umol s^{-1} m^{-2}), and rolled wheat residue resulted in lower light penetration (431 umol s^{-1} m^{-2}) compared to standing wheat residue (671 umol s^{-1} m^{-2}) 4 WAT. At the November 15th planting date, standing cereal rye residue resulted in lower light penetration (608 umol s^{-1} m^{-2}) compared to the rolled cereal rye residue (1036 umol s^{-1} m^{-2}) 4 WAT. There was no significant difference in weed control by termination method. At the September 15th planting date, rolled cereal rye residue resulted in the lowest light penetration compared to standing and rolled wheat residue 4 and 6 WAT. At the October 15th planting date, cereal rye residue, regardless of termination method, resulted in the lowest light penetration compared to wheat residue 4 and 6 WAT. Cereal rye produced the greatest cover crop biomass (9244 – 4599 kg ha^{-1}) compared to wheat (5453 – 1843 kg ha^{-1}) at all planting dates.

BOLL DISTRIBUTION AND YIELD RESPONSE TO SIMULATED DICAMBA DRIFT ON NON-DICAMBA TOLERANT COTTON (*GOSSYPIUM HIRSUTUM*). K. R. Russell*, P. A. Dotray, G. L. Ritchie; Texas Tech University, Lubbock, TX (295)

ABSTRACT

The adoption of dicamba-tolerant cotton (*Gossypium hirsutum*) will increase the number of preplant and postemergence applications of dicamba for control of glyphosate-resistant Palmer amaranth (*Amaranthus palmeri* S. Wats), which also will increase the risk of off target movement to non-target crops. A field study was conducted at the Texas Tech New Deal Research Farm equipped with subsurface drip irrigation in 2017 and 2018 to evaluate cotton response to dicamba when applied at four crop growth stages (first square + two weeks, first flower, first flower + two weeks, and cutout). Dicamba (Clarity 4L) at 0.56 (1X), 0.056 (1/10X), 0.0112 (1/50X), 0.0056 (1/100X), and 0.00112 (1/500X) kg ae/ha was applied at 140 l/ha using TTI11004 nozzles. Plots, four 102-cm rows by 9.1 m, were replicated three times. A 1.5 m sample of cotton was collected from a row center of each plot and the bolls were removed and placed in a grid box based on node and sympodial fruiting position just prior to harvest. Each boll was recorded by fruiting site, and bolls were weighed in cohorts corresponding with first position bolls between nodes 4 and 8, nodes 9 through 11, and nodes 12 and above. Second position bolls were grouped with first position bolls two nodes higher based on the similarity of flowering dates on the plant. Plots were machine harvested to determine lint yield and fiber analysis determined at the Texas Tech Fiber and Biopolymer Institute. Visual cotton injury at each application timing was rate dependent and injury was noted from all dicamba rates 0.0056 and greater. Injury symptomology following each dicamba rate varied with application timings and in general was greatest following the first square + two weeks applications. Visual injury ranged from 3 to 77% following first square + two weeks applications, whereas injury ranged from 0 to 47% following applications made at first flower + two weeks. Lint yield was reduced following dicamba at 0.56 kg ae/ha at all application timings in 2017, but no yield loss from this rate was observed in 2018. Lint yield was reduced in both 2017 and 2018 when dicamba was applied at 0.056 kg ae/ha at first square + two weeks, first flower, and first flower + two weeks. At the cutout application, no lint reduction was observed following the 0.056 kg ae/ha application of dicamba. The greatest change in boll distribution followed the 0.0112, 0.056, and 0.56 kg ae/ha dicamba rates applied at first square + two weeks and first flower.

EXAMINING ENVIRONMENTAL FACTORS AND CHEMICAL CONTROL OPTIONS FOR JUNCUS SPECIES. Z. D. Small*[1], J. D. McCurdy[2], J. T. Brosnan[3], J. D. Byrd, Jr.[1], T. Tseng[1], E. Reasor[4], M. P. Richard[5]; [1]Mississippi State University, Mississippi State, MS, [2]Mississippi State University, Mississippi State University, MS, [3]U of TN 252 Ellington Bldg, Knoxville, TN, [4]PBI-Gordon Corporation, Shawnee, KS, [5]Mississippi State University, Starkville, MS (296)

ABSTRACT

Path rush (*Juncus tenuis*) is a problematic weed in maintained turfgrass. This species favors compacted, moist environments where turf is weakened. Auxin mimicking herbicides have traditionally been used to control this species with mixed results. Greenhouse research at Mississippi State University was conducted to determine herbicide control options as well as environmental factors that contribute to weediness of path rush. A greenhouse rate response study was conducted in a completely randomized design (4 replications, repeated twice in time) to test the hypothesis that path rush populations differed in response to halosulfuron (0.07 kg ai ha^{-1}), 2,4-D (1.06 kg ae ha^{-1}), and a combination of the two. Herbicide application rates doubled from 0.25 to 32× aforementioned rates. For the combination treatment, halosulfuron was increased, while the rate of 2,4-D was held constant at the 1× rate. Three path rush populations failed to differ in herbicide response, thus results were combined across treatment. High rates (≥4×) of halosulfuron or 2,4-D were required to achieve ≥80% control of rush species. The effects of 2,4-D (0.25 to 32× rate) were neither enhanced nor diminished by the addition of halosulfuron (0.07 kg ai ha^{-1} kg ai ha-1), and neither halosulfuron nor 2,4-D provided acceptable control at standard use rates.

A separate greenhouse study was conducted as a completely randomized design to test the hypothesis that path rush plant vigor is related to soil moisture and compaction levels. A 3×3 factorial arrangement of treatments sought to determine what environmental factors contribute to path rush above and below ground biomass accumulation. Path rush plugs (three per experimental unit) were acclimated for 2 weeks prior to exposure to a factorial of three levels of soil moisture (10.9, 27.9, and 59.6 %VWC) and three levels of soil compaction (1573, 1750, and 2003 kg m^{-3}). Biomass accumulation was measured 6 weeks after study initiation by clipping shoots and roots. Clippings were weighed after drying for 48 hours at 70°C. Results from this study indicate that soil compaction and moisture may be independently significant to shoot and root growth; however, no interaction effect existed between them.

A field study was conducted to determine ideal application timings for control of path rush. This study was designed as a randomized complete block with 4 replications. Single applications of halosulfuron (0.07 kg ai ha^{-1}) and Trimec Classic (1.52 kg ai ha^{-1}) were made once a month from October to March in a water carrier volume of 187 L ha^{-1}. Early fall applications appear to be optimal for both herbicides, as both October treatments and the November halosulfuron treatment were the only two applications that visually controlled path rush greater than the non-treated check, 12 weeks after treatment.

WEEDY RICE GENOMIC REGIONS CONTRIBUTING TO ALLELOPATHY. B. C. Schumaker*[1], T. Tseng[2], S. Shrestha[3], S. D. Stallworth[2]; [1]Mississippi State University, Starkville, MS, [2]Mississippi State University, Mississippi State, MS, [3]Texas A&M, College Station, TX (297)

ABSTRACT

Rice provides up to 50% of the dietary caloric supply for an estimated 520 million people worldwide. Increasing productivity of rice production is paramount to meet the demand of a growing global population. The most significant yield constraint in rice production is weed competition. Weeds are successful in the field in part because of their genetic diversity, allowing them to adapt and thrive in various environments. Weedy rice is one of the most problematic rice weeds, exhibiting characteristics that suggest a vast germplasm of potential traits for cultivated rice crop improvement. One such trait exhibited in weedy rice is allelopathy. Allelopathy is defined as any detrimental effect by one plant on another through the production of chemical compounds that escape into the environment. Incorporation of allelopathic traits into cultivated rice lines may improve growth habits and assist in overcoming yield losses due to weeds. The overall objective of this study is to evaluate the genetic diversity among selected weedy rice accessions, cultivated rice (CL163, REX) and allelopathic rice (RONDO, PI312777, PI338047), using 30 SSR markers. Nei's genetic diversity among weedy rice (0.4) was found to be higher than cultivated rice (0.24) but less than allelopathic rice (0.56). Population structure and genetic relationship regarding allelopathic potential was evaluated. No distinction was observed between allelopathic and non- allelopathic weedy rice accessions. Accession B2 was found to be genetically distinct than the other weedy rice accessions and possessed high allelopathic potential. This information will be helpful for ongoing rice breeding efforts.

THE INTERACTION OF PLANT CUTTING AND BURNDOWN HERBICIDES ON HORSEWEED CONTROL TO IMPROVE MANAGEMENT IN DOUBLE-CROP SOYBEANS FOLLOWING WHEAT. C. P. Carmody*[1], K. L. Gage[1], R. F. Krausz[2]; [1]Southern Illinois University, Carbondale, IL, [2]Southern Illinois University, Belleville, IL (298)

ABSTRACT

Abstract

Double-cropping winter wheat (*Triticum aestivum* L.) and soybeans (*Glycine max* (Merr) L.) may allow producers in southern Illinois to harvest two crops from the same field in a given year. No-till practices typically associated with double-crop soybeans may cause an increase in populations of small-seeded broadleaf weeds such as horseweed (*Conyza canadensis* (L.) Cronquist), which germinates from shallow soil depths. Horseweed in the United States has developed resistances to ALS-inhibitors, EPSP synthase-inhibitors, PSI electron diverters, and PSII-inhibitors; and long-distance wind dispersal of horseweed creates management challenges impacting large geographies. Properly stewarded glufosinate- or dicamba-resistant soybean systems may be reliable methods for controlling herbicide-resistant horseweed populations; however, efficacy of these technologies must be preserved. In a double-crop system, horseweed plants may reach diameters of 7.5 cm or greater and bolting stage by wheat harvest, when weeds are cut to wheat harvest height. In order to improve stewardship of glufosinate- and dicamba-resistant soybean technologies following a winter wheat crop, a two-year field study was established in Carbondale, Illinois, at a location with > 70% frequency of glyphosate-resistant horseweed. The objective of the study was to evaluate the effects of cutting height, herbicide applications, and timing of herbicide application on the control of horseweed and other weeds. Plots were 3 m by 9 m and were divided into 3 m sub-plots to test the effect of cutting height. Cutting treatments were: uncut, 15 cm cutting height, and 30.5 cm cutting height. Herbicide applications were: nontreated; dicamba + glyphosate (1682.8 g ai ha^{-1}) + saflufenacil (25 g ai ha^{-1}); dicamba + glyphosate (1682.8 g ai ha^{-1}) + metribuzin (420.7 g ai ha^{-1}); dicamba + glyphosate (1682.8 g ai ha^{-1}) + flumioxazin (73.6 g ai ha^{-1}) + chlorimuron (25.3 g ai ha^{-1}); dicamba + glyphosate (1682.8 g ai ha^{-1}) + sulfentrazone + cloransulam (314.1 g ai ha^{-1}), dicamba + glyphosate (1682.8 g ai ha^{-1}); glyphosate (1267.7 g ai ha^{-1}); paraquat (1121.9 g ai ha^{-1}); glufosinate (656.3 g ai ha^{-1}); and dicamba (560.9 g ai ha^{-1}). Herbicide application timings were: immediately after cutting or 5 days after cutting. Weed control rating were taken at 7, 14, 21, and 35 days after treatment (DAT) for horseweed, Canada goldenrod (*Solidago canadensis* L.), and common ragweed (*Ambrosia atrimesifolia* L.) in 2017 and horseweed only in 2018. Data were analyzed using a three-way ANOVA to observe the effects of cutting height, herbicide treatment, and application timing on percent visual weed control. Treatments containing dicamba in 2017, provided 86-99% control of horseweed with dicamba + glyphosate + saflufenacil resulting in the greatest control (99%) of all treatments. The dicamba + glyphosate + metribuzin treatment resulted in the least control (86%) and was the only treatment containing dicamba that had similar control efficacy to paraquat (84%). Contact herbicides glufosinate and paraquat were observed to have comparable weed control to one another at 81 and 84%, respectively. Glyphosate alone resulted in the least overall control (7%) at 35 DAT in 2017. Treatments in 2018 followed a similar trend to that of 2017 for horseweed control 35 DAT. However, contrary to 2017 results, glufosinate provided greater horseweed weed control (94%) than paraquat (86%) in 2018 and was comparable to all products containing dicamba except dicamba + glyphosate + metribuzin (89%) at 35 DAT. Results suggested that all herbicide treatments benefited from cutting horseweed to 15 cm except dicamba + glyphosate + saflufenacil and dicamba + glyphosate when comparing applications made to non-cut plants in 2018 at 35 DAT. Across all treatments and both years, 15 cm cutting height provided greater weed control over the 30 cm cutting height and the uncut treatments. Applications made five days following cutting were observed to increase the control of horseweed for dicamba + glyphosate + metribuzin, and dicamba + glyphosate + flumioxazin + chlorimuron; all other systemic herbicides followed the same trend but were not statistically different from one another in 2017 at 35 DAT. Conversely, contact herbicides paraquat and glufosinate were observed to have increased weed control when applications were made immediately following cutting of horseweed in 2017 at 35 DAT. Common ragweed control was >90% for all treatments 35 DAT in 2017. Common ragweed weed control based on application timing and treatment resulted in increased control when applications were applied immediately following cutting for the herbicides glyphosate and glufosinate. Lastly, the effect of cutting height on the perennial, rhizomatous species, Canada goldenrod, differed from horseweed, in that cutting at 15 cm resulted in lower control efficacy than cutting at 30 cm or uncut treatments. Canada goldenrod control regarding application timing and treatment was similar to horseweed; delayed applications to cut Canada goldenrod increased control of systemic herbicides while earlier applications increased control of contact herbicides 35 DAT in 2017. In conclusion, mechanical cutting of weeds to 15 cm height during winter wheat harvest may increase control efficacy of herbicide treatments on large annual weeds, and therefore, may be a component of stewardship of soybean technologies in a wheat double-crop system.

COMPARISON OF NOZZLE TYPE AND APPLICATION PRESSURE ON WEED CONTROL IN PEANUT. K. L. Broster*[1], J. Ferguson[1], T. A. Baughman[2], B. Zurweller[3], B. Rushing[4]; [1]Mississippi State University, Mississippi State, MS, [2]Oklahoma State University, Ardmore, OK, [3]Mississippi State University, Starkville, MS, [4]Mississippi State University, Newton, MS (299)

ABSTRACT

Comparison of Nozzle Type and Application Pressure on Weed Control in Peanut (*Arachis hypogaea*)

Peanuts are an important cash crop for the United States, and Mississippi produced 33 million dollars of peanuts in 2017 (USDA-NASS, 2018). Peanuts have a prostrate growth pattern, making it easy for weeds to shade the crop canopy, and interfere for nutrients, water, and light. An important part of weed control is nozzle selection, and proper application methods. The purpose of this study is to determine the most effective nozzle type and operating pressure for a season long weed control program. A field study was conducted at Mississippi State University, RR Foil Plant Science Research Center in Starkville, Mississippi. A runner type peanut, Georgia 06G, was used and herbicide applications were made at three different timings: pre-emergent (PRE), early post-emergent (POST) (cracking), and late POST. Weed control ratings were collected 7, 14, 28, 42, and 56 days after the late POST. Yield data was collected at harvest and used to determine the most effective application method for season long weed control. The data indicates that there is not a significant difference in terms of nozzle, pressure, or adjuvant addition effects on peanut yield. However there is a difference on weed control when looking at pressure by nozzle, and pressure alone. This infers that different techniques, like pressure, affect weed control, but it is more important to have an effective weed management program, based on the nozzles all having similar droplet size and no effect on yield.

SCALING UP BRAZILIAN PEPPERTREE (*SCHINUS TEREBINTHIFOLIA)* IPT RESEARCH WITH CONTRACTORS IN SOUTH FLORIDA. M. E. Bell*; University of Florida, Gainesville, FL (300)

ABSTRACT

Scaling Up Brazilian Peppertree (*Schinus terebinthifolia)* IPT Research with Contractors in South Florida. M. Bell*, S. F. Enloe, University of Florida, Gainesville, FL.

Brazilian peppertree is an invasive shrub that infests more than 280,000 hectares in Florida. Its rapid growth and spread require state agencies to aggressively manage it at an annual cost of one to two million dollars per year. Contractors who do this work frequently use triclopyr ester applied as a basal bark treatment. This treatment is very effective; however, it can be time-intensive, costly, and quickly approach the maximum label rate per acre. Recent research has indicated that aminocyclopyrachlor and aminopyralid have shown promise in controlling Brazilian peppertree in a novel reduced hack and squirt approach, where single injections are made to each major stem. However, this approach has not been tested operationally and it is critical to determine its utility for contractors. We hypothesized that compared to a commercial standard basal bark application, the reduced hack and squirt approach would be similar in time required, provide a significant reduction in herbicide applied, and provide similar control. This experiment was conducted in June 2018 in South Florida on a site that consists of a dense monoculture of Brazilian peppertree. Twenty-four plots, each approximately 0.5-acres in size were established in a grid. Two six person contractor crews were trained on the novel approach, and assigned 12 plots to treat. Four treatments included a typical basal bark method, the reduced hack and squirt approach with either aminopyralid or aminocyclopyrachlor, and an untreated control. All treatments were replicated on the three plots per contractor crew and arranged in a completely randomized design. Data collected included crew time to treat each plot, amount of herbicide mix applied, and percent defoliation following 60 and 180 days after treatment (DAT). There was no significant difference in application time between treatments, but there was a difference between crews. Aminopyralid resulted in lower efficacy compared to reduced hack and squirt with aminocyclopyrachlor and traditional basal bark at 180 DAT. With the novel approach, aminocyclopyrachlor and aminopyralid provided significant reductions in total herbicide applied compared to triclopyr ester applied as a basal bark treatment. This unique contractor based research approach has accelerated our understanding of a novel invasive plant treatment strategy and its implementation in the field.

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DROPLET SIZE EFFECTS ON PREEMERGENCE HERBICIDE EFFICACY IN SOYBEAN. P. H. Urach Ferreira[1], L. H. Merritt*[2], D. B. Reynolds[1], J. T. Irby[1], G. Kruger[3], J. Ferguson[1]; [1]Mississippi State University, Mississippi State, MS, [2]Mississippi State University, MS State, MS, [3]University of Nebraska-Lincoln, North Platte, NE (301)

ABSTRACT

Unlike post-emergence herbicides (POST), little is known about the droplet size effect on pre-emergence herbicides (PRE) efficacy. Four nozzle types were used to spray different PRE herbicides on eight soybean fields in Mississippi and Missouri in 2017 and 2018. Five herbicides, pendimethalin, metribuzin, clomazone, imazethapyr and pyroxasulfone, were selected based on their physicochemical characteristics including adsorption, volatility and solubility. Nozzle types used were XR 11002, ULD 12002, TTI60 11002 and TTI 11002 nozzles. The XR nozzle produced the smallest droplet size (DV0.5), 204 μm, followed by the ULD, TTI60 and TTI with DV0.5 of 468, 646 and 794 μm, respectively. Droplet size, spray coverage, nozzle type or physicochemical characteristics did not impact PRE herbicide efficacy, except in one field for one herbicide. The TTI60 twin fan nozzle significantly enhanced pendimethalin weed control by 91% in a high organic matter (OM) soil comprised of large clods and high weed pressure. This was due to increased herbicide contact with the soil and greater herbicide clod coverage. When soils had a higher OM content (> 2%) pendimethalin reduced weed control. When conditions included soils with low OM (< 0.7%), low cation exchange capacity (< 13.1%), and rainfall of 12.2 mm within 3 days after application, metribuzin was observed to show reduced weed control. The results indicate that droplet size does not affect PRE herbicide efficacy while nozzle type (i.e. dual fan nozzles like the TTI60), can enhance weed control in specific herbicide-field conditions.

EFFICACY OF HPPD-INHIBITING HERBICIDES APPLIED PREEMERGENCE OR POSTEMERGENCE FOR CONTROL OF MULTIPLE RESISTANT WATERHEMP (*AMARANTHUS TUBERCULATUS* VAR. *RUDIS*). L. Benoit*[1], P. Sikkema[2], D. Hooker[3], D. Robinson[2]; [1]University of Guelph, Kirkton, ON, [2]University of Guelph, Ridgetown, ON, [3]University of Guelph, Ridge, ON (302)

ABSTRACT

Waterhemp (Amaranthus tuberculatus) is a competitive, highly-prolific, summer annual, broadleaf weed. Waterhemp populations resistant to up to three herbicide modes-of-action, Groups 2, 5 and 9, have been recorded at 48 locations in Ontario from a survey conducted in 2014 and 2015. A survey was conducted in 2016 and 2017 to identify additional sites with herbicide-resistant waterhemp in Eastern Canada. Waterhemp seed was collected from 23 new location through random and directed field scouting, 32 in Ontario and 1 in Quebec. Waterhemp was screened in the greenhouse for resistance to: imazethapyr (75 g ai ha-1), atrazine (1000 g ai ha-1), glyphosate (900 g ae ha-1), and lactofen (110 g ai ha-1), representing Group 2, 5, 9 and 14 herbicides,respectively. Of the 23 samples collected in 2016-17: 100% of the sites had biotypes that were resistant to imazethapyr, 88% to atrazine, 84% to glyphosate and 43% to lactofen. Forty-three percent of the populations had individual plants with resistance to all four herbicides. This is the first report of a Group 14 weed in Eastern Canada. Field studies were conducted in 2017 and 2018 to determine the relative efficacy of Goup 27 herbicides plus atrazine, applied PRE or POST, for the control of multiple-resistant waterhemp in corn. At 4 weeks after application (WAA), isoxaflutole + atrazine and mesotrione + atrazine, applied preemeergence, controlled waterhemp 93 and 91%, respectively. At 4 WAA, topramezone + atrazine and mesotrione + atrazine, applied postemergence, controlled waterhemp 87 and 93%, respectively.

OUT WITH THE OLD WORLD CLIMBING FERN, IN WITH THE NEW: EVALUATION OF FLORPYRAUXIFEN-BENZYL AND TRICLOPYR FOR *LYGODIUM MICROPHYLLUM* CONTROL IN SOUTH FLORIDA. J. S. Glueckert*[1], S. F. Enloe[2]; [1]University of Florida, Boynton Beach, FL, [2]University of Florida, Gainesville, FL (303)

ABSTRACT

Old World Climbing Fern (*Lygodium microphyllum*) or OWCF, is one of the most aggressive invasive plants in South and Central Florida. This highly invasive fern smothers native vegetation, overtopping tree canopies, and dominating the understory community with thick rachis mats. Native to Africa, Asia, and Australia, OWCF was first detected in Martin County, FL in the 1960's and has since expanded its range throughout South and Central Florida, with isolated populations ranging as far north as Jacksonville. OWCF is one of the most difficult invasive plants to manage due to its wind dispersed spores, tolerance to flooding, and tendency to grow in areas with challenging access. While prior research has found that glyphosate and metsulfuron can provide effective control of OWCF, advances in OWCF management have been limited over the past 10 years and the fern continues to thrive in mesic upland and wetland ecosystems. In 2016 a partnership was formed between the University of Florida, Florida Fish and Wildlife Commission, South Florida Water Management District, and the US Fish and Wildlife Service to reinvigorate research into best management practices for OWCF. An aggressive herbicide screening program was initiated to examine short and long-term efficacy, minimize non-target damage, and examine these aspects in relation to fluctuating hydrology, and temporal and geographical variation. Fifteen different herbicides at varying rates were tested in over 400 5x5 meter plots in dense infestations in South and Central Florida from 2016 through 2018. From these tests, two herbicides, triclopyr and florpyrauxifen-benzyl, were observed to have good efficacy on OWCF. Multiple triclopyr formulations reduced OWCF cover to less than 10% at 180 days after treatment. However, at 360 days after treatment, herbicide performance varied between locations, possibly due to temporal and hydrological variations. Florpyrauxifen-benzyl at 1L/ha and 2L/ha resulted in OWCF cover less than 5% at 180 days after treatment while the lower rate of 500mL/ha did not provide effective control. Based on these results, these herbicides may be alternative options to glyphosate and metsulfuron. Additional research with both active ingredients is ongoing in Loxahatchee National Wildlife Refuge to assess larger-scale treatment operations. Currently, 60 individual tree islands in the Loxahatchee NWR have been treated by contractors by backpack and aerial application with both triclopyr and florpyrauxifen-benzyl treatments. These treatments are currently being monitored for OWCF control and non-target damage. These studies will assist land managers in improving OWCF management with new tools and approaches that are desperately needed.

PHYSIOLOGICAL PARAMETERS OF VELVETLEAF UNDER NORMAL AND ELEVATED CO_2 TREATED WITH TEMBOTRIONE. J. C. Argenta*[1], Q. Ruchel[2], S. Finlayson[1], T. Gentry[1], M. V. Bagavathiannan[1], K. Carson[1]; [1]Texas A&M University, College Station, TX, [2]Federal University of Pelotas, Pelotas, Brazil (304)

ABSTRACT

The current atmospheric CO_2 concentration of 400 ppm will increase to a concentration of 700-1000 ppm by the year 2100, according to the IPCC (Intergovernmental Panel on Climate Change). Climate change will have a crucial effect on agriculture production by influencing weed growth and herbicide efficacy. The objective of this study is to evaluate the efficacy of tembotrione – Laudis® in controlling velvetleaf (*Abutilon theophrasti*) under an elevated CO_2 concentration. Tembotrione was applied at 0.3x and 0.5x of the recommended dose when plants were at V2-V3 stage, under two concentrations of carbon dioxide, 400 ppm and 700 ppm. Herbicide injury was evaluated at 10 and 21 days of application, and carbon photosynthetic assimilation rate (A, μmol CO_2 m^{-2} s^{-1}) was measured 10 DAT as well . Statistical analyses were conducted using JMP® Pro v. 14.20, and consisted of analysis of variance (ANOVA) and significant differences by LSD – Fisher's test. Results show that the higher CO_2 treatment had a negative effect on herbicide injury. At 21 DAT both herbicide doses showed higher injury at 400 ppm, which indicates that the higher CO_2 concentration reduced tembotrione efficacy. No significant difference was observed in the carbon photosynthetic assimilation rate between the two CO_2 treatment levels. For this preliminary study, we conclude therefore an increase in the concentration of carbon dioxide will reduce the efficacy of tembotrione in controlling velvetleaf.

PPO ARG128 SUBSTITUTIONS: WHAT ARE THE OPTIONS? K. Lillie*[1], P. Tranel[2], J. Lerchl[3], A. Porri[4]; [1]University of Illinois, Urbana, IL, [2]University of Illinois, Urbana, IL, [3]BASF SE, Limburgerhof, Germany, [4]BASF SE, Ludwigshafen am Rhein, Germany (305)

ABSTRACT

Protoporphyrinogen oxidase (PPO)-inhibiting herbicides have been used for over fifty years to control weeds in agronomic crops. Since the loss of glyphosate control due to widespread glyphosate resistance across the US, growers have relied heavily on PPO-inhibiting herbicides and, thus, concerns were raised over selection for resistance to them. These concerns were realized when the first case of resistance to PPO-inhibiting herbicides occurred in 2001 in *Amaranthus tuberculatus*. The first known mechanism of PPO-inhibitor resistance is the deletion of a glycine codon in the PPO gene, *PPX2*, corresponding to amino acid position 210. The second mechanism evolved in *Ambrosia artemisiifolia*, and it involves a *PPX2* mutation that substitutes an arginine for a leucine at the 98^{th} amino acid position. More recently, two mutations involving an amino acid change at the homologous site in *Amaranthus palmeri* (R128) have been discovered that involve an amino acid change from arginine to either glycine or methionine. The objectives of this study are to characterize the remaining sixteen amino acid changes that could occur at this site to determine whether they result in a functioning enzyme and what level of resistance they confer, as well as to test their effect when coupled with the dG210 mutation. Constructs encoding the different mutations were cloned, expressed in *E. coli*, and purified for in vitro enzyme assays. Dose responses were carried out in which lactofen, fomesafen, saflufenacil, or trifludimoxazin at a range of rates were added to each enzyme modification. The mutations R128D, R128E, R128P, and R128W were found to render the enzyme inactive, while the remaining mutations resulted in active enzymes with different levels of resistance. Trifludimoxazin provided the greatest inhibition of both the single and double mutant enzymes, followed by lactofen. Fomesafen and saflufenacil had the lowest levels of inhibition against the single mutants, and neither one inhibited the

double mutants. These results indicate additional R128 substitutions conferring resistance to PPO inhibitors can evolve in weeds, but acceptable control of such weeds might still be possible with trifludimoxazin.

IS THE GRASS GREENER?: OPTING FOR GRAMINICIDES OVER BROAD SPECTRUM HERBICIDES FOR WEST INDIAN MARSH GRASS CONTROL. K. H. Quincy*, S. F. Enloe; University of Florida, Gainesville, FL (306)

ABSTRACT

West Indian marsh grass (*Hymenachne amplexicaulis*), or WIMG, is a perennial, stoloniferous species that forms monocultures in freshwater marshes across South and Central Florida. Research in similar habitats in Australia has shown WIMG invasions alter native plant, insect, and fish communities. Typically, broad-spectrum herbicides such as glyphosate and imazapyr are used for control; however, their non-target impacts can be severe on native plant species. The recent availability of the grass specific herbicides (graminicides) sethoxydim and fluazifop-p-butyl for aquatic testing in Florida prompted field and mesocosm studies to improve WIMG control and reduce non-target impacts. Our specific objective was to evaluate the efficacy of graminicides on WIMG and non-target impacts on native grass species. Field plots on Cypress Lake, near Kissimmee, FL, were treated in the fall of 2017 with broadcast rates and spot treatment concentrations of fluazifop and sethoxydim, each with 1% v/v MSO as an adjuvant. The graminicides provided at least 90% WIMG control at 30 and 90 DAT when compared to the untreated control with no significant differences between treatments. At 90 DAT, a 62 to 84% decline was recorded in native grass species cover monitored at the site, which included *Leersia hexandra*, *Luziola fluitans*, and *Paspalum distichum*. All graminicides provided up to 50% control of WIMG at 280 DAT. Plots were retreated on August 30, 2018 and preliminary results at 30 and 90 DAT are similar to the first treatment. Continued springtime monitoring in 2019 is expected to reveal longer-term responses of both the target and non-target grasses. Additionally, a mesocosm study was conducted to compare the responses of five native grasses (*Sacciolepis striata*, *Paspalidium geminatum*, *Panicum hemitomon*, *L. fluitans*, and *L. hexandra*) to glyphosate and both graminicides. At 60 DAT, no significant difference was found between graminicides and untreated controls when measuring total biomass for *P. hemitomon*, *L. hexandra*, and *L. fluitans*. For the remaining species, the only graminicide treatment that displayed significantly lower biomass was sethoxydim. Total biomass at 60 DAT was significantly lower in glyphosate treatments when compared to the untreated control for all species except *L. fluitans*. These data indicate the graminicides may have a good fit in aquatic systems for WIMG control and improved selectivity over glyphosate. kquincy@ufl.edu

ACCURACY AND EFFICIENCY OF HERBICIDE APPLICATIONS OF AN INTEGRATED SYSTEM USING AN UAV-SPRAYER AND REMOTE SENSOR-GENERATED WEED MAP. J. E. Hunter*, R. E. Austin, R. Richardson, T. Gannon, J. Neal, R. Leon; North Carolina State University, Raleigh, NC (307)

ABSTRACT

Unmanned aerial vehicles (UAVs) have been used in agriculture to collect time accurate imagery for monitoring and decision making purposes. Spray capable UAVs have been introduced to the marketplace for conducting liquid pesticide applications. This technology has been intended for broadcast dispersal, but limitations due to battery duration and payload capacity severely limits its value for large scale agriculture. Combining UAV imagery and spraying technologies can offer a new technique to simulate site-specific weed management. However, limited research has been conducted to evaluate the accuracy, efficiency, and off-target movement of UAV applied herbicides. The present study was conducted to identify critical differences between UAV site-specific and conventional ground-based broadcast weed management strategies, and also quantify the efficacy and efficiency of herbicide applications. The results indicated that broadcast management were more accurate at targeting weeds, but less precise, efficacious, and efficient than UAV management. The efficiency of UAV management practices decreased as weed population density and distribution increased. In conclusion, bundling UAV imagery and spray technology can provide a new strategy for integrated weed management programs to improve efficiency and efficacy while reducing the amount of herbicide being applied.

INTERVAL BETWEEN SEQUENTIAL GLUFOSINATE APPLICATIONS INFLUENCES WEED CONTROL IN COTTON. T. M. Randell*[1], L. C. Hand[1], J. C. Vance[1], A. S. Culpepper[2]; [1]University of Georgia, Tifton, GA, [2]University of Georgia, Tifton, GA (308)

ABSTRACT

Auxin-based systems allow producers to effectively manage glyphosate-resistant Palmer amaranth (*Amaranthus palmeri* S. Wats) in cotton. Due to the susceptibility of Georgia's diverse agricultural production systems and potential for off-target movement, an auxin alternative is needed for use in these sensitive areas. Glufosinate-based systems offer limited off-target movement concerns, however labeled sequential POST applications ($\geq$ 10 d between applications) offer variable control especially when weeds are larger than 10 cm. Studies were conducted at five locations during 2017 and 2018 investigating the optimum time interval between sequential POST applications to improve the effectiveness of the system. The experimental design was a split-plot with the whole-plot being the interval between sequential applications (1, 3, 5, 7, 10 or 14 d), and herbicide option (glufosinate 656 g ai ha^{-1} alone or mixed with glyphosate 1,261 g ae ha^{-1}) as the sub-plot. A no POST 2 treatment was also included and all herbicides were applied at 140 L ha^{-1}. Combined over four locations, 15-20 cm tall Palmer amaranth was controlled over 97% by glufosinate with sequential intervals of 1 to 7 d, which was up to 13% greater than 10 or 14 d intervals. Palmer amaranth biomass measurements, taken from the entire plot (4 by 3 m), noted similar weights with intervals between 1 and 10 d. Mixing glyphosate with glufosinate did not influence control or biomass. At the fifth location, Palmer amaranth 46-56 cm tall was controlled 89-93% by sequential glufosinate applications having a 1 to 5 d interval, compared to 75-79% control with 7 to 14 d intervals. Biomass weights ranged from 329-608 kg ha^{-1} with intervals of 1 to 5 d compared to 842-2,942 kg ha^{-1} with 7 to 14 d intervals. When pooled over intervals, mixing glyphosate with glufosinate improved control by 4% but did not influence biomass. Large crabgrass (*Digitaria sanguinalis* (L.) Scop.) 15-20 cm tall was present at four locations. Control ranged from 76-81% when glufosinate was applied sequentially with 10 to 14 d intervals; 12 to 22% greater control was noted with 3 to 7 d intervals. Mixing glyphosate with glufosinate improved grass control when glufosinate alone provided less than 92% control. Large crabgrass biomass samples at harvest were at their lowest with intervals between 1 and 10 d. Treatments did not influence cotton yield at the four locations with smaller Palmer amaranth. At the fifth location with large Palmer amaranth, cotton yield was greater than 4,397 kg ha^{-1} with sequential application intervals of 1 to 5 d compared to less than 3,578 kg ha^{-1} when intervals were 7 d or greater. Results suggest timely sequential POST applications of glufosinate can improve control of Palmer amaranth and large crabgrass, and may offer an effective alternative to auxin-based systems in sensitive areas.

WEED MANAGEMENT IN ISOXAFLUTOLE-RESISTANT SOYBEAN USING A TWO-PASS HERBICIDE PROGRAM. A. Smith*[1], A. Kaastra[2], D. Hooker[3], D. Robinson[4], P. Sikkema[4]; [1]n/a, Ancaster, ON, [2]Bayer CropScience, Guelph, ON, [3]University of Guelph, Ridge, ON, [4]University of Guelph, Ridgetown, ON (309)

ABSTRACT

Transgenic crops are being developed with herbicide resistance traits to provide innovative weed control options. Soybean conferring resistance to the group 27 herbicide; isoxaflutole, is currently under development and will provide a novel herbicide mode of action for use in soybean. Field experiments were conducted in 2017 and 2018 on five unique soil types using isoxaflutole resistant soybean to evaluate annual weed control efficacy of PRE applied isoxaflutole and metribuzin at three different rate combinations including the low rate 52.5 and 210 g a.i. ha^{-1}, medium rate 79 and 315 g a.i. ha^{-1}, high rate 104 and 420g a.i. ha^{-1} of isoxaflutole and metribuzin respectively. These treatments were applied alone and with an application of glyphosate (900 g a.i. ha^{-1}) POST when weed escapes from the PRE applied herbicides were 7.5cm tall. Control of lamb's quarters, and common ragweed differed between locations. Less control was seen at locations which received lower amounts of cumulative rainfall between the PRE and POST applications. All other species did not differ between locations. In general broadleaf weed control with the low rate ranged from 25 to 69%, control with the medium rate ranged between 49 and 86% and the high rate controlled broadleaf weeds between 71 and 95%. Grass weeds were controlled between 85 and 97% with the low rate, 75 and 99% with the medium rate and 86 to 100% with the high rate. All weeds were controlled 98 to 100% when a POST application of glyphosate was applied regardless of the rate of isoxaflutole and metribuzin applied PRE. To conclude, increasing rates of isoxaflutole and metribuzin provided better control of annual weeds and glyphosate applied post provided control of escaped weeds.

EVALUATION OF QUIZALOFOP MIXTURE INTERACTIONS WITH REDUCED RATES OF HALOSULFURON IN PROVISIA RICE. C. Webster*[1], E. P. Webster[2], B. McKnight[2], S. Rustom[2], D. C. Walker[2]; [1]Louisiana State University, Baton Rouge, AL, [2]Louisiana State University, Baton Rouge, LA (310)

ABSTRACT

Evaluation of Quizalofop Mixture Interactions with Reduced Rates of Halosulfuron in Provisia Rice

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Imidazolinone resistant (IR) weedy rice (*Oryza sativa* L.) and barnyardgrass [*Echinochloa crus-galli* (L.) P. Beauv.] resistance prompted BASF to develop an acetyl coenzyme A carboxylase (ACCase) resistant (ACCase-R) rice (*O. sativa* L.) to be sold under the tradename of Provisia®. The targeted herbicide for use is quizalofop, a member of the aryloxyphenoxypropionate herbicide family.

A study was conducted in 2017 and 2018 at the H. Rouse Caffey Rice Research Station near Crowley, Louisiana to evaluate the antagonistic, synergistic or neutral interactions of quizalofop when mixed with reduced rates of halosulfuron. Plot size was 1.5 by 5.1 m with eight, 19.5 cm drill-seeded rows of ACCase-R 'PVL01' long grain rice. Eight, 19.5 cm drill-seeded rows of IR 'CLXL-745' and 'CL-111' were planted perpendicular to the PVL01 at 84 kg ha^{-1}. Awnless red rice was broadcasted at 50 kg ha^{-1} across the research area, and the area was naturally infested with barnyardgrass.

The study was a randomized complete block with a two-factor factorial arrangement of treatments with four replications. Factor A consisted of postemergence (POST) applications of quizalofop at 0 and 120 g ai ha^{-1}. Factor B consisted of POST applications of halosulfuron at 0, 17, 35, and 53 g ai ha^{-1} or a pre-packaged mixture of halosulfuron and thifensulfuron at 34 and 53 g ai ha^{-1}. At 28 days after the initial treatment (DAIT), a second application of quizalofop was applied at 120 g ha^{-1}. All herbicide applications were applied with a crop oil concentrate at 1% v v^{-1}. Visual evaluations for this study included barnyardgrass, red rice, CL-111 and CLXL-745 control at 14 and 28 DAIT. Control data were analyzed using the Blouin augmented mixed model to determine synergistic, antagonistic, or neutral responses for herbicide mixtures by comparing an expected control calculated based on activity of each herbicide applied alone to an observed control. Rice yields were obtained and adjusted to 12% moisture.

At 14 DAIT, antagonism of quizalofop occurred when mixed with all rates of halosulfuron or halosulfuron plus thifensulfuron for barnyardgrass, CL-111, CLXL-745 and red rice control. At 28 DAIT, an antagonistic response was observed for barnyardgrass control when quizalofop was mixed with halosulfuron plus thifensulfuron at 53 g ha^{-1}, respectively. Expected control for barnyardgrass was 98%, compared with an observed control of 79%. At the same rating interval, a neutral interaction was observed for control of barnyardgrass with an expected control of 98%, compared with the observed control of 96%, when quizalofop was mixed with halosulfuron plus thifensulfuron at 34 g ha^{-1}. At 28 DAIT, antagonism of quizalofop occurred when mixed with halosulfuron at 17 and 35 g ha^{-1} or halosulfuron plus thifensulfuron at 17 and 53 g ha^{-1} for CL-111, CLXL-745 and red rice control. At 28 DAIT, neutral responses were observed when quizalofop was mixed with halosulfuron at 53 g ha^{-1} for CL-111, CLXL-745 and red rice control.

In conclusion, this research indicates that reduced rates of halosulfuron or halosulfuron plus thifensulfuron in a mixture with quizalofop will result in neutral interactions in Louisiana rice production.

VARIATION IN HERBICIDE PERFORMANCE ON *KALANCHOE* CONTROL IN FLORIDA DUNE COMMUNITIES. J. Solomon*; University of Florida, Gainesville, FL (311)

ABSTRACT

Kalanchoe is a genus of succulent plants from Madagascar in the Crassulaceae family that was first documented in the United States in the 1920's and was likely introduced through the ornamental and medicinal plant trade. It has since become invasive in many areas of Florida but is especially problematic in sensitive coastal dune communities. Information on management of *Kalanchoe spp.* is limited and control has proven very difficult due to the high fecundity and rapid dispersal of the numerous plantlets produced along the leaf margins. One of the primary species of concern is *Kalanchoe xhoughtonii,* which has been vouchered around the state as invading natural areas. The extremely high propagule pressure created by the plantlets has produced carpets of *Kalanchoe*, as observed in St. Augustine Beach, FL. Hand pulling this type of succulent in beach dunes has shown to generate an immense disturbance that does not sufficiently remove the majority of the smaller plantlets hiding within the native vegetation. To address this growing problem, multiple studies were initiated in the Spring of 2018 at the UF Center for Aquatic and Invasive Plants in Gainesville, Florida. Greenhouse screenings of a wide range of herbicide active ingredients with multiple modes of action were evaluated on *Kalanchoe xhoughtonii* adult plants and plantlets using standard foliar broadcast application techniques. Post treatment measurements of defoliation and plantlet development were taken every fifteen days until mortality or recovery was observed. We observed significant variation in *Kalanchoe* control among auxin type herbicides. Triclopyr and aminocyclopyrachlor were very effective while florpyrauxifen-benzyl provided poor control. Among amino acid biosynthesis inhibitors imazapyr, imazamox, and glyphosate were effective. However, penoxsulam did not control Kalanchoe, as treated plants continued to develop viable plantlets post treatment. Other herbicides with contact type activity such as diquat resulted in rapid

foliar burndown but plants recovered quickly from axillary buds. We also observed strong differences in herbicide efficacy across modes of action at different life history stages; carfentrazone controlled *Kalanchoe* plantlets but did not effectively control older, well established plants. These studies provide clear direction for upcoming field studies where efficacy and selectivity of specific auxin type herbicides and amino acid biosynthesis inhibitors will be examined in sensitive dune communities.

EVALUATION OF EARLY AND LATE-SEASON MARESTAIL MANAGEMENT IN SOYBEANS. H. Summers*[1], D. Lingenfelter[2], H. Karsten[1]; [1]Pennsylvania State University, University Park, PA, [2]Penn State University, University Park, PA (312)

ABSTRACT

In Pennsylvania, over 65% of agronomic crops are produced without tillage, resulting in heavy reliance on glyphosate-tolerant crops and increased selection pressure for glyphosate-resistant weeds. Marestail (*Erigeron canadensis* L.) is a prolific seed producer with wind-dispersed seed, making it the most common glyphosate-resistant weed in Pennsylvania and some nearby states. Using new and existing soybean variety technologies, we examined burndown versus post-emergence (POST) activity on native marestail. All burndown treatments contained glyphosate (1.27 kg ae ha^{-1}), metribuzin (0.21 kg ae ha^{-1}), and flumioxazin (0.09 kg ae ha). Core-burndown programs included 2,4-D (0.56-1.23 kg ae ha^{-1}) or dicamba (0.56 kg ae ha^{-1}) followed by glyphosate POST. Core-POST programs contained 2,4-D, dicamba, or glufosinate (0.62 kg ae ha^{-1}). To increase diversity, we added two mechanical programs: a chisel-disc operation before soybeans and an oats/sorghum sudangrass forage. We hypothesized that mechanical programs would control marestail similarly to core-burndown programs, and both would be more effective than core-POST programs. We expected all treatments to reduce marestail survival and biomass better than glyphosate-only. Ten treatments were compared in 4.6 by 6.1-meter plots in a randomized complete block design replicated five times at the Russell E. Larsen Agronomy Farm in Rock Springs, Pennsylvania. Before the burndown application, marestail plants in each plot were categorized and marked by growth stage and size into four categories: i. rosette, less than 5-cm diameter ii. rosette, greater than 5-cm diameter iii. bolting, less than 10-cm tall, and iv. bolting, greater than 10-cm tall. Ten weeks after soybean planting, all marestail plants were harvested and measured for dry matter. Glyphosate-only had 200% higher marestail biomass than mechanical, core-burndown, and core-POST programs. Few plants categorized in rosette stages survived. Mechanical and core-burndown programs significantly reduced bolting marestail survival compared to glyphosate-only, while the Core-POST programs did not.

THE EFFECTIVENESS OF INTEGRATED TACTICS FOR MANAGING JOHNSONGRASS IN INZEN SORGHUM. B. L. Young*[1], N. E. Korres[2], L. M. Lazaro[3], M. J. Walsh[4], J. K. Norsworthy[2], M. V. Bagavathiannan[1]; [1]Texas A&M University, College Station, TX, [2]University of Arkansas, Fayetteville, AR, [3]Louisiana State University AgCenter, Baton Rouge, LA, [4]University of Sydney, Narrabri, Australia (313)

ABSTRACT

Non-transgenic sorghum (Inzen™ sorghum) tolerant to nicosulforon, an acetolactate synthase (ALS) inhibitor, will soon be available for commercial production. This technology will allow the POST application of nicosulfuron (labeled as Zest®) for controlling grass weeds such as johnsongrass in grain sorghum. Development of best management practices and stewardship protocols are critical for long-term sustainability of the Inzen™ technology. The objective of this experiment was to evaluate several integrated tactics for managing johnsongrass in Inzen™ sorghum. Field experiments were conducted in 2016, 2017, and 2018 at College Station, TX, in areas with high densities of johnsongrass infestation. The treatments included 1) S-metolachlor PRE followed by (fb) Atrazine applied POST at 30 cm tall sorghum (standard practice in conventional sorghum), 2) S-metolachlor PRE fb Atrazine plus nicosulfuron POST (standard weed management program in Inzen™ sorghum), 3) Program #2 with glyphosate as desiccant prior to harvest, 4) Program #3 with chaff removal (removal of johnsongrass seedheads) at harvest, 5) Program #4 with shredding and disking the field after harvest and treat the johnsongrass-regrowth with clethodim, and 6) Program #5, except no chaff removal at harvest. Program #1 increased its totals of johnsongrass from 2016 with 51,857 plants per hectare to 2018 with 71,232 plants per hectare as compared to program #2 which reduced from 76,821 to 3,607 plants per hectare over the three year period. Programs 3,4,5, and 6 were the most effective after 3 years with numbers between 7-21 johnsongrass plants. Integration of multiple weed management tactics obtained from this research will be useful in minimizing the risk of resistance evolution in johnsongrass and will ensure the sustainability of the Inzen™ sorghum technology.

POTENTIAL SAFENING OF TOPRAMEZONE ON CREEPING BENTGRASS (*AGROSTIS STOLONIFERA* L.) WITH ADDITIVE PRODUCT COMBINATIONS. C. G. Goncalves*[1], J. M. Peppers[1], A. M. Brown[2], J. S. McElroy[2]; [1]Auburn University, auburn, AL, [2]Auburn University, Auburn, AL (314)

ABSTRACT

Creeping bentgrass response to topramezone is highly variable and is influenced by rates, tank mixes, and environment condition. The specifics of such factors remain poorly understood. The objectives of this research were to evaluate (study 1) topramezone (Pylex) injury at different application timing and (study 2) potential safening of topramezone by combination with paclobutrazol (Trimmit 2SC), Fe chelate (Sprint 330) or a turfgrass pigment (Sarge 2.0). Field treatments for study 1included applications of Pylex alone at (5.2, 10.4, 15.6, or 20.8 g ai/ha) all applied in April, May, June or July and for study 2 three sequential applications of Pylex (5.2 or 10.4 g ai/ha) alone and in combination with Trimmit 2SC (98.1 g ai/ha), Sprint 330 (610.3 g ai/ha), or Sarge 2.0 (1.68 kg/ha). Results from study 1 indicate early season application of topramezone are safe to creeping bentgrass at all rates used. Topramezone application in July caused greatest creeping bentgrass injury, likely due to the high temperatures that stressed the turfgrass during this period. In general, injury from topramezone increased from April to July applications. For study 2, application of topramezone in combination with paclobutrazol, Fe chelate, or turfgrass pigment reduced visual turfgrass injuries compared to topramezone applied alone. Treatments that included paclobutrazol application programs were the most efficient because it increased turfgrass quality and reduced bleaching injuries caused by topramezone. We conclude that early applications and combination of paclobutrazol, Fe chelate, or turfgrass pigment could safely be used on creeping bentgrass putting greens.

WEED CONTROL EFFICACY AND CHRISTMAS TREE TOLERANCE TO PRE AND POSTEMERGENCE HERBICIDES. J. S. Aulakh*; The Connecticut Agricultural Experiment Station, Windsor, CT (315)

ABSTRACT

Field experiments were conducted at multiple locations in Connecticut to evaluate the weed control efficacy and Christmas tree tolerance to pre- and postemergence herbicides. The preemergence herbicides safety and efficacy trial (PRE) in a newly transplanted Canaan fir (*Abies balsamea* var. phanerolepis) at Hamden had a randomized complete block design with 3 replications. Herbicide treatments consisted of two levels of each of Lumax® (s-metolachlor + atrazine + mesotrione), Marengo® (indaziflam), Sureguard® (flumioxazin), and Westar® (hexazinone + sulfometuron methyl). Herbicides were applied before bud-break with a compressed CO_2

sprayer fitted with single OC-3 nozzle to make a semi-directed application in 2016 and over-the-top in 2017 using two XR Teejet 8002 nozzles at 20 GPA. The postemergence herbicides safety trial (POST) at Windsor and Griswold was a completely randomized design with 12 trees per treatment. Herbicide Panoramic 2SL (imazapic) was applied over-the-top of actively growing Norway spruce (*Picea abies*) and white pine (*Pinus strobus*) at Windsor on June 26, 2018 and Douglas fir (*Pseudotsuga menziesii*), Nordman Fir (*Abies nordmanninana*) and Turkish Fir (*Abies nordmanninana ssp. equi-trojani*) at Griswold on July 10, 2018 with a compressed CO_2 sprayer fitted with single XR Teejet 11003 nozzle delivering 30 GPA at 32 psi. In the PRE trial by 12 WAT, horseweed (*Conyza canadensis*), large crabgrass (*Digitaria sanguinalis*), red sorrel (*Rumax acetocella*), wild carrot (*Daucus carota*), and yellow foxtail (*Setaria pumila*) were controlled ≥ 80% with Lumax® and Westar® regardless of application rate. Marengo® at 7.5 floz/a and Sureguard® at ≥ 6 floz/a controlled horseweed and large crabgrass ≥ 80% but red sorrel and wild carrot control was not satisfactory. Yellow foxtail control with Marengo and Sureguard ranged from 45 to 82%. Canaan fir was not injured by any of the herbicide treatments over the two study years. In the POST trial, Douglas fir, Norway spruce, and white pine were observed to be highly tolerant to 'Panoramic 2SL' up to 24 floz/a. However, Nordman fir, and Turkish fir showed significant chlorotic injury which did not exceed 20% by 14 WAT. Similarly, leader length in both Nordman and Turkish firs was reduced with 'Panoramic 2SL' rates higher than 6 floz/a.

DEEP LEARNING WITH CONVOLUTIONAL NEURAL NETWORK: A METHOD FOR PRECISION WEED CONTROL IN TURFGRASS. J. Yu*[1], A. W. Schumann[2], S. M. Shaun[2], N. Boyd[1]; [1]University of Florida, Balm, FL, [2]University of Florida, Wimauma, FL (316)

ABSTRACT

Turfgrass is the most ubiquitous form of vegetation cover in urban landscape. Weeds generally occur in patchy and non-uniform distribution in turfgrass. Spot-spraying herbicides can significantly decrease herbicide input and weed management cost. However, manual spot-spraying in large turfgrass areas is unfeasible. Deep learning with convolutional neural network (DLCNN) may provide an opportunity for real-time weed detection in machine vision-based smart sprayers. We trained several DLCNN models for detection of dandelion (*Taraxacum officinale* Web.), ground ivy (*Glechoma hederacea* L.), and spotted spurge (*Euphorbia maculata* L.) growing in perennial ryegrass (*Lolium perenne* L.) turfgrass. The neural networks were trained using a dataset containing a total of 15486 negative images (images contained perennial ryegrass with no target weeds) and 17600 positive images (images contained target weeds). VGGNet achieved high F_1 scores (≥0.93), with high recall values (≥0.99) at detecting *Euphorbia maculata, Glechoma hederacea,* and *Taraxacum officinale* growing in perennial ryegrass. The F_1 scores of AlexNet ranged from 0.84 to 0.94 for detection of *Euphorbia maculata*, *Glechoma hederacea*, and *Taraxacum officinale*. DetectNet achieved high F_1 scores (≥0.98) for detection of *Taraxacum officinale*. Overall, we conclude that VGGNet and DetectNet are highly suitable for a machine vision-based decision system in smart sprayers for precision weed control in perennial ryegrass turfgrass.

EVALUATION OF NEWLY ESTABLISHED BUFFALOGRASS FOR TOLERANCE TO GLYPHOSATE. M. B. Bertucci*, D. Karcher, M. Richardson, D. OBrien; University of Arkansas, Fayetteville, AR (317)

ABSTRACT

Buffalograss (*Buchloë dactyloides*) is a warm-season grass native to the US Great Plains and exhibits many desirable characteristics as a turf for home lawns or moderately trafficked areas. Buffalograss is ideal for low maintenance environments due to its reduced irrigation and fertility requirements and slower growth rate. Observations during herbicide screenings revealed a degree of tolerance and a recuperative ability of mature buffalograss following application with glyphosate. Because glyphosate is an inexpensive, general-use herbicide, it would be useful in low input systems where buffalograss is currently used. However, it is not clear whether newly established buffalograss seedlings have similar tolerance to glyphosate. Thus, the present study was designed to investigate the effects of glyphosate rates and application timings in newly seeded buffalograss. 'Cody' buffalograss was seeded into prepared sites in Fayetteville, AR on June 21 and May 19 in 2017 and 2018, respectively. Six glyphosate rates were included for this study: 10, 255, 510, 1,020, and 2041 g ae ha^{-1} and one untreated control. Three glyphosate applications were timed at 1, 3, or 8 wk after emergence (WAE), relative to when 50% of buffalograss seedlings had emerged. Glyphosate rates and application timings were crossed in a factorial treatment arrangement in a randomized complete block design and replicated three times. Visual ratings of turf quality were assessed at 10 weekly intervals in each year, starting one week after initial glyphosate application. Digital images were recorded using a portable lightbox and digital camera twice per week over a 10 wk period. Subsequent image analysis calculated percent coverage and dark green color index at each rating period. In 2017, unacceptable injury was observed at all application timings when glyphosate was applied at 255 g ha^{-1} or above. Buffalograss injury was slightly reduced in 2018, and unacceptable injury was observed when glyphosate was applied at 510 g ha^{-1} or above. In 2018, early applications (1 WAE) of glyphosate at 255 g ha^{-1} rate caused unacceptable injury during initial ratings, but the buffalograss subsequently recovered to meet the minimum acceptable standard for turf quality. In 2018, glyphosate applied at 255 g ha^{-1} at 8 WAE did not result in unacceptable injury. Based on the results of the present study, buffalograss has some ability to withstand lower levels of glyphosate at specific growth stages. However, glyphosate applications at these rates and timings after emergence cause an unacceptable amount of injury to buffalograss and would not be a commercially viable option for weed management.

EFFICACY OF AVENUE SOUTH IN TALL FESCUE (*FESTUCA ARUNDINACEA*). J. Derr*, A. Nichols; Virginia Tech, Virginia Beach, VA (318)

ABSTRACT

There is a need for a broadleaf herbicide that is both safe and effective in both cool- and warm-season turfgrass. One possible fit for this need is a four way combination of 2,4-D, dicamba, penoxsulam, and sulfentrazone being sold under the trade name Avenue South. Experiments were conducted to evaluate the efficacy of this combination herbicide in tall fescue (*Festuca arundinacea* Schreb.). Any impact from the addition of a water-soluble nitrogen fertilizer, urea ammonium nitrate, to the spray tank was also determined. The herbicide was applied at 3.8, 7, or 14 L/ha with or without a tank mix with a 30-0-0 fertilizer on May 16, 2017 and on June 21, 2017. It was compared to the combination product containing 2,4-D, dicamba, MCPP, and carfentrazone sold under the trade name Speedzone Southern. This herbicide was applied at 8.4 L/ha with or without the 30-0-0 fertilizer. When applied on May 16, injury to tall fescue was apparent 1 day after treatment (DAT) when fertilizer was added to Avenue South or Speedzone Southern but no injury was seen at this time when fertilizer was not added. Tall fescue injury increased as the rate of Avenue South increased when fertilizer was added. All treatments containing fertilizer caused significantly greater injury to tall fescue compared to the herbicides applied without fertilizer from 2 DAT through 23 DAT. At 14 DAT, turf injury was unacceptable at all rates of Avenue South applied with fertilizer. The injury observed was significant yellowing, tip burning, and stand thinning. Speedzone Southern applied without fertilizer to tall fescue did not cause any injury. Injury from Avenue South applied without fertilizer was slower to appear. Avenue South at all rates applied without fertilizer injured tall fescue from 14 DAT through 23 DAT, with injury increasing as the rate increased. At 30 DAT, Avenue South at 14 L/ha caused greater injury than that rate applied with fertilizer. Little to no injury to tall fescue was noted 30 DAT when Avenue South was applied

with fertilizer. The injury seen in plots treated with Avenue South without fertilizer was yellowing and growth suppression. The injury was most likely due to the penoxsulam component within Avenue South causing the growth regulation. Tall fescue was injured by Avenue South applied with fertilizer after the second application, but overall injury levels were much lower than that seen after the first application. No injury was seen when Avenue South was applied at any rate without fertilizer when applied in June. Tall fescue growth stage appears to affect injury potential from Avenue South. The turf may have had more tender growth at the May compared to the June application. Brown patch disease was increased with the addition of the fertilizer compared to the same rate without fertilizer, though the difference was not always significant. Adding fertilizer to Avenue South caused a rapid, contact injury. Injury from Avenue South applied without fertilizer was slower to develop. Tall fescue can be injured by applications of Avenue South, especially when applied with nitrogen fertilizer.

PREEMERGENCE CONTROL OF *PRAXELIS CLEMATIDEA,* AN EMERGING WEED IN FLORIDA NURSERIES. C. Marble*[1], N. Boyd[2], S. T. Steed[3]; [1]University of Florida, Apopka, FL, [2]University of Florida, Balm, FL, [3]University of Florida/IFAS Extension, Seffner, FL (319)

ABSTRACT

Praxelis clematidea (praxelis) is an annual or short-lived perennial herb in the Asteraceae family and native to South America. Praxelis was first discovered in Orange County, Florida in 2006 and has since been confirmed in six other Central Florida counties. Praxelis has recently been observed in Florida container nurseries, but is often confused with *Ageratum houstonium* (bluemink) which is morphologically similar and is a common weed in container and field nurseries in Central and South Florida. Currently, there is no preemergence efficacy data available for either species in container nursery production. The objective of these experiments was to determine efficacy of common preemergence herbicides labeled for use in container nurseries for control of praxelis and bluemink, and to determine if differences in response existed between these two similar species. Container trials were conducted in Apopka and Balm, FL in 2018 using standard pine bark: peat nursery potting media and control release fertilizers at standard manufacturer label rates. After containers were filled with potting media, herbicides including indaziflam (0.09 kg ai ha^{-1}), flumioxazin (0.4 kg ai ha^{-1}), dimethenamid-P (1.7 kg ai ha^{-1}), dimethenamid-P + pendimethalin (1.7 + 2.2 kg ai ha^{-1}), oxyfluorfen + pendimethalin (2.2 + 1.1 kg ai ha^{-1}), oxyfluorfen + prodiamine (2.2 + 0. kg ai ha^{-1}), prodiamine + isoxaben (1.7 + 1.1 kg ai ha^{-1}), and trifluralin + isoxaben (4.5 + 1.1 kg ai ha^{-1}) were applied using either a CO_2 backpack sprayer for spray-applied treatments (indaziflam, dimethenamid-P, prodiamine + isoxaben) or a hand-shaker for granular treatments (all others). Nontreated controls were maintained for comparison. In Apopka, 50 seeds of praxelis and bluemink were overseeded two days after treatment to separate containers and received overhead irrigation throughout the trial. Data collected included weed counts at 4 and 10 weeks after treatment (WAT) and shoot dry weights at 10 WAT. Similar procedures were followed in Balm except only praxelis was evaluated and weed counts were recorded bi-weekly for 9 weeks. Counts and dry weights were converted to percent control (percent reduction) based on the nontreated control groups. Across both locations, flumioxazin, oxyfluorfen + pendimethalin and oxyfluorfen + prodiamine provided the most consistent praxelis control with 97% + reductions in counts and dry weight. Indaziflam provided 100% praxelis control in Apopka but only 22% control in Balm while prodiamine + isoxaben provided 100% in Balm but only 74% control in Apopka. Dimethenamid-P results also differed by location, as only 42% control was observed in Apopka and 74% control observed in Balm. Dimethenamid-P + pendimethalin and trifluralin + isoxaben provided <50% at both locations. In Apopka, bluemink control was similar to that observed with praxelis with the exception of dimethenamid-P and dimethenamid-P + pendimethalin, which provided 75 to 98% control of bluemink but only 0 to 42% control of praxelis. Prodiamine + isoxaben also provided 98% control of bluemink but only 74% control of praxelis. Results indicate that current preemergence herbicides, especially those containing oxyfluorfen or flumioxazin could be used to manage praxelis and bluemink in container nurseries. While other herbicides showed efficacy, results were inconsistent across locations. Results also show it is important to identify and distinguish between these two species as results differed with dimethenamid-P containing products and prodiamine + isoxaben.

GREENHOUSE AND FIELD EVALUATION OF PREEMERGENCE HERBICIDE EFFECTS UPON NATIVE WARM SEASON GRASS ESTABLISHMENT FOR GOLF COURSE ROUGHS. M. P. Richard*[1], J. D. McCurdy[2], B. S. Baldwin[1], J. I. Morrison[3]; [1]Mississippi State University, Starkville, MS, [2]Mississippi State University, Mississippi State University, MS, [3]Mississippi State University, Mississippi State, MS (320)

ABSTRACT

Perennial native warm season grasses are slow to establish, making seedlings poor competitors with weeds during establishment. Commonly used turfgrass preemergence herbicides control troublesome annual weeds, but little is known about their effects upon native grass establishment. Greenhouse and field research was conducted at Mississippi State University from 2016 to 2018 to evaluate the effects of imazapic, prodiamine, dithiopyr, pendimethalin, atrazine, simazine, oxadiazon, metolachlor, dimethenamid, isoxaben, and indaziflam on the establishment of little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), indiangrass (*Sorghastrum nutans*), purpletop tridens (*Tridens flavus*), upland switchgrass (*Panicum virgatum*), and sideoats grama (*Bouteloua curtipendula*). In both studies, seeds were planted at a 0.6 cm depth into a native Marietta silt loam soil. In the greenhouse study, 10 seed of each species were sown in 53 cm^3 conetainers. In the field study, a 50/50 little bluestem and sideoats grama seed mixture were drilled seeded at 16 kg ha^{-1}. Herbicide treatments were applied in a water carrier volume of 374 L ha^{-1} immediately after planting. Research was conducted as a completely randomized design with 4 replications, replicated twice in time. Response variables included germination, plant count, total ground cover, and crabgrass control. The greenhouse studies indicated that atrazine, simazine, isoxaben, oxadiazon, and pendimethalin had little effect upon germination of most native grass species. In the field study, herbicide effects on native grass establishment were species dependent. Combining the parameters of crabgrass control and relative plant density, imazapic was the best herbicide option. Across studies, imazapic, atrazine, simazine, and isoxaben may have utility in warm season native grass establishment if slight reduction in plant numbers can be tolerated.

STRATEGY FOR THE CONTROL OF PANIC LIVERSEEDGRASS (*UROCHLOA PANICOIDES*) IN DESERT TURF. K. Umeda*; University of Arizona, Phoenix, AZ (321)

ABSTRACT

Panic liverseedgrass has become more noticeable and problematic as a summer annual weed in lower maintenance turf areas in central Arizona. It has been a noxious turf weed in southern Arizona since 2007 after it was introduced through Texas and New Mexico after originating in Africa and moving through Asia to South America and Mexico. It was previously reported that topramezone and mesotrione demonstrated limited activity and that quinclorac products, metsulfuron, and sulfosulfuron were not effective against maturing stands of liverseedgrass. Preemergence herbicides prodiamine, pendimethalin, dithiopyr, dimethenamid, flumioxazin, and indaziflam applied during the winter in December or February provided varying periods of weed control after emergence in early March. Prodiamine and pendimethalin gave good control into July with December applications. December applications of most of the preemergence treatments were more effective longer than February treatments. During the summer of 2018, postemergence herbicides were applied sequentially on mature liverseedgrass. The pre-mix product foramsulfuron plus halosulfuron plus thiencarbazone gave nearly acceptable control of 79% at 3 weeks after the two applications. Pinoxaden and the pre-mix product iodosulfuron plus dicamba plus thiencarbazone

demonstrated initial activity following the first application but control was not acceptable after the second application. Amicarbazone exhibited liverseedgrass growth reduction within a week after the second application but control was not acceptable 3 weeks after. A foreseeable strategy against liverseedgrass will be a winter application of a preemergence herbicide followed by a postemergence treatment while liverseedgrass is immature. Validation of preemergence followed postemergence treatments is in progress as is the refinement of earlier timing of single versus sequential postemergence applications.

SWITCHBLADE™: A NON-2,4-D OPTION FOR CONTROL OF WEEDS IN TURFGRASS. E. Reasor*[1], J. W. Marvin[2], B. A. Aynardi[3], R. C. Williamson[4]; [1]PBI-Gordon Corporation, Shawnee, KS, [2]PBI-Gordon Corporation, Overland Park, KS, [3]PBI-Gordon Corporation, State College, PA, [4]PBI-Gordon Corporation, Defiance, OH (322)

ABSTRACT

SwitchBlade™ is a selective herbicide that includes the novel active ingredient halauxifen-methyl. Halauxifen-methyl is an 6-aryl-picolinate which is a synthetic auxin herbicides (WSSA Group 4). Coupled with fluroxypyr and dicamba, SwitchBlade™ has the potential to be a non-2,4-D herbicide option for control of various broadleaf weed species. Field trials from 2016 to 2018 at various research facilities throughout the U.S. evaluated SwitchBlade™ efficacy on economically important broadleaf weeds. Weed species included broadleaf plantain (*Plantago major*), buckhorn plantain (*Plantago lanceolata*), dandelions (*Hypochaeris radicata* and *Taraxacum officinale*), dollarweed (*Hydrocotyle umbellata*), doveweed (*Murdannia nudiflora*), lawn burweed (*Soliva sessilis*), prostrate knotweed (*Polygonum aviculare*), Virginia buttonweed (*Diodia virginiana*), and white clover (*Trifolium repens*). SwitchBlade™ was applied at three or four pints acre^{-1} using CO_2-pressurized boom sprayers calibrated to deliver 20 to 40 gal acre^{-1}. A non-treated check and commercially available herbicides were included for comparison. Experiments included three to four replications and plot size varied among research locations. Percent weed control was visually assessed by each researcher according to their preferred method of rating. Assessments occurred from seven to ninety-one days after application at regular intervals depending on weed species and research location. Analysis of variance and Fisher's Protected Least Significant Difference (α=0.05) was performed on percent weed control in ARM Software (v.2018; Gylling Data Management, Inc.; Brookings, South Dakota). SwitchBlade™ applied at three or four pints acre^{-1} resulted in greater than 80% control across all weed species targeted and was statistically greater than or similar to commercially available herbicides. A four-week sequential SwitchBlade™ application at four pints acre^{-1} was required to provide effective control (>90%) of prostrate knotweed. A single application SwitchBlade™ application at four pints acre^{-1} yielded 90 to 95% Virginia buttonweed control; although, a sequential application would likely greater control. Overall, SwitchBlade™ provided consistent control of many economically important broadleaf weed species and will become a non-2,4-D containing herbicide available for turfgrass managers.

NATIONAL OVERVIEW OF WEED SEEDS AND PHYTOSANITARY RESTRICTIONS IN FOREIGN TRADE. R. Bishop*; USDA-APHIS, Fort Collins, CO (323)

ABSTRACT

Soybeans are critical to the U.S. economy. In 2017, the United States exported 55.2 million metric tons of soybeans valued at $21.4 billion, making them one of the country's top exports. One of the most significant plant health issues facing U.S. soybeans is weed seeds. Many countries are taking increasingly stringent action when they detect weed seeds in imported commodities. Actions include additional inspections, treatment, or other measures to reduce pest risk. In the worst case, a country could close market access entirely.

To help U.S. soybean producers overcome this potential trade barrier, APHIS has collaborated with other USDA agencies, industry, and academia, to develop a systems approach designed to reduce weed seeds in U.S. soybean exports. The systems approach is a suite of recommended weed management, production, harvesting, and handling best practices to reduce weed seed contamination. This strategy has helped the U.S. industry maintain uninterrupted access to key foreign markets.

COSTS AND BENEFITS OF A 1% CAP ON FOREIGN MATERIAL IN US SOYBEAN EXPORTS. S. Naeve*; University of Minnesota, St. Paul, MN (324)

ABSTRACT

The relative quality of commodities has been primarily assigned based on traditional grain grading standards. One important measure within these standards is Foreign Material or FM. While important to end users, the composition of the FM has only rarely been the focus of much attention. FM can enter the soybean value chain at any point, and the composition of the FM is greatly impacted by where it appears within the stream. While purchasers often complain about FM in imported soybeans, exporters claim hardship in supplying clean grain and charge higher rates for #1 grain. The end result is a value chain that does not reward sourcing and maintaining clean grain throughout. A recent requirement by Chinese authorities stipulates that US shipments of soybean must contain less than 1% FM and it prioritizes weed seed contaminants within the FM fraction. This action will require the US trade to produce, store, and transport clean soybeans. It is our contention that producing a higher quality product will serve US farmers and trade well in the long run. This session will highlight our interactions with international purchasers and our efforts to measure and promote high quality US soybeans globally.

ELIMINATING WEED SEEDS AT SOYBEAN HARVEST: LESSONS LEARNED FROM THE AREA-WIDE IWM TEAM. S. B. Mirsky*[1], J. K. Norsworthy[2], A. S. Davis[3], M. V. Bagavathiannan[4], S. C. Beam[5], J. A. Bond[6], K. Bradley[7], W. S. Curran[8], J. Evans[9], W. Everman[10], M. L. Flessner[5], G. Frisvold[11], N. R. Jordan[12], L. M. Lazaro[13], J. Lindquist[14], L. S. Shergill[7], L. E. Steckel[15], M. J. VanGessel[16]; [1]USDA-ARS, Beltsville, MD, [2]University of Arkansas, Fayetteville, AR, [3]N-319 Turner Hall, Urbana, IL, [4]Texas A&M University, College Station, TX, [5]Virginia Tech, Blacksburg, VA, [6]Delta Research and Extension Center, Stoneville, MS, [7]University of Missouri, Columbia, MO, [8]Penn State University, Bozeman, MT, [9]Farmscape Analytics, Concord, NH, [10]North Carolina State University, Raleigh, NC, [11]University of Arizona, Tucson, AZ, [12]University of Minnesota, St. Paul, MN, [13]Louisiana State University AgCenter, Baton Rouge, LA, [14]University of Nebraska, Lincoln, NE, [15]University of Tennessee, Jackson, TN, [16]University of Delaware, Georgetown, DE (325)

ABSTRACT

THE BEST-LAID PLANS FOR WEEDS BY MAN SOMETIMES GO AWRY. A. Hager*; University of Illinois, Urbana, IL (326)

ABSTRACT

China drafted new grain import regulations in 2016 designed to reduce the introduction of invasive weed species, primarily as weed seeds. Subsequently, China informed the United States Department of Agriculture that some U.S. soybean grain shipments did not comply with the regulations. Estimates place one of every three U.S.-produced soybean bushels is imported by China, making this country the largest market for U.S. soybean and highlighting the need for reducing weed seed contamination in soybean shipments. China reported detections of 36 different weed species from U.S. soybean imports in 2017, however approximately 80 percent of these seeds were from species listed as ragweed, cocklebur, Johnsongrass and pigweed. This presentation will discuss aspects of common cocklebur, Johnsongrass, giant ragweed, and waterhemp biology that might be contributing to these species success as weeds in U.S. soybean production.

WHAT WEED SEEDS ARE ACTUALLY FOUND IN SOYBEAN GRAIN SAMPLES IN LOUISIANA. L. M. Lazaro*[1], J. T. Copes[2], D. O. Stephenson[3], D. Miller[4], A. Orgeron[1]; [1]Louisiana State University AgCenter, Baton Rouge, LA, [2]Louisiana State University AgCenter, Saint Joseph, LA, [3]Louisiana State University AgCenter, Alexandria, LA, [4]Louisiana State University AgCenter, St. Joseph, LA (327)

ABSTRACT

Sixty-percent of all agricultural products come down the Mississippi River to Louisiana to be exported. China is the primary importer of United States (US) soybean and maintains a 1% standard for foreign material (FM) in soybean grain shipments. Many US contracts, however, still operate at a 2% threshold. China recently raised concerns to the USDA about FM levels with respect to quarantine weed seeds. Four weed species, ragweed, cocklebur, Johnsongrass, and pigweed, have been detected in nearly 80% of US soybean shipments to China. However, there is little research on which weed species or the quantity of weed seeds contained in the FM of specific soybean growing regions. Thus, this preliminary experiment examined what precisely constitutes the FM of Louisiana soybean grain when delivered at the grain elevator. Twenty-five samples were obtained from a total of three-grain elevators in Louisiana. The samples collected were separated out by material and weighed. The weed seed present were counted and identified to the species level. The samples comprised of 2 to 33% FM, with 0 to 7% of the FM containing weed seeds. In total, seven weed seeds were found in the samples. Of those species, only Johnsongrass and pigweed were of primary concern. These species comprised an average of 0 to 4.5% of the total FM. We recognize that the small sample set does not represent all soybean producing areas within Louisiana, but it does provide a baseline of information to proceed to more detailed experiments. Understanding the level or and what constitutes the FM in soybean in Louisiana from farm to port is essential in helping our growers.

WEED SEEDS, PHYTOSANITARY RESTRICTIONS, AND TRADE IMPLICATIONS. L. Van Wychen*[1], S. P. Conley[2]; [1]WSSA, Alexandria, VA, [2]University of Wisconsin, Madison, WI (328)

ABSTRACT

THE EFFECT OF MULTIPLE DICAMBA EXPOSURES ON SOYBEAN GROWTH AND YIELD. J. A. Bond[1], K. Bradley[2], N. Corbin[3], K. L. Gage[4], M. Loux[5], E. J. Miller[6], J. K. Norsworthy[7], D. B. Reynolds*[8], L. E. Steckel[9], B. G. Young[10]; [1]Delta Research and Extension Center, Stoneville, MS, [2]University of Missouri, Columbia, MO, [3]Mississippi State University, Stoneville, MS, [4]Southern Illinois University, Carbondale, IL, [5]Ohio State University, Columbus, OH, [6]Southern Illionois University, Carbondale, IL, [7]University of Arkansas, Fayetteville, AR, [8]Mississippi State University, Mississippi State, MS, [9]University of Tennessee, Jackson, TN, [10]Purdue University, Brookston, IN (329)

ABSTRACT

COMPARATIVE RESPONSES OF NON-DICAMBA TOLERANT SOYBEAN VARIETIES TO DICAMBA. O. Osipitan*[1], J. E. Scott[1], S. Z. Knezevic[2]; [1]University of Nebraska-Lincoln, Concord, NE, [2]University of Nebraska-Lincoln, Lincoln, NE (330)

ABSTRACT

Control of broadleaf weeds with dicamba has been encouraging, resulting in increased adoption of dicamba-tolerant (DT) soybeans. However, the off-target movement of dicamba-based products to non-DT soybeans has become a serious concern. Thus, field studies were conducted in 2017 and 2018 to evaluate the relative sensitivity of conventional, glufosinate-tolerant and glyphosate-tolerant soybeans to micro-rates of three dicamba-based herbicide products (Clarity® [dicamba diglycolamine]; Engenia® [dicamba N,N-Bis-(3-aminopropyl) methylamine]; and XtendiMax® [dicamba diglycolamine with Vapor Grip technology]) applied at three soybean growth stages (V2, R1 and R2 stages). The dicamba micro-rates were 0, 0.56, 1.12, 5.6, 11.2, and 56 g ae ha^{-1}; equivalent to 0, 1/1000, 1/500, 1/100, 1/50, and 1/10 of the standard rate (560 g ae ha^{-1}) respectively. The experimental design was a randomized complete block design in a split-split-plot arrangement with 4 replications. The three evaluated soybeans were equally sensitive to the micro-rates of the three dicamba products. The visual injuries and yield loss ranged from 20-80% and 0-96% respectively, depending on the growth stage of dicamba application and dicamba rate. The estimated effective doses (ED values) suggested that conventional, glufosinate-tolerant and glyphosate-tolerant soybeans exposed to dicamba micro-rates at R1 growth stage were more sensitive than those exposed at V2 and R2 growth stages. Based on the ED values, about 0.1% of dicamba standard rate was enough to cause 10% soybean yield loss when applied at R1 stage; while about 1% of dicamba standard rate was required to cause the same level of yield loss when applied at V2 or R2 stage. By implication, dicamba drift from any of the dicamba-based herbicides on non-DT soybean plants should be avoided to prevent yield loss.

DICAMBA DURABILITY IN ROUNDUP READY® XTEND CROP SYSTEM. N. Rana, S. Evans*; Bayer CropScience, St Louis, MO (331)

ABSTRACT

EFFECT OF CARRIER VOLUME AND SPRAY QUALITY ON SOYBEAN RESPONSE TO DICAMBA. B. Sperry*[1], J. Calhoun[1], D. B. Reynolds[2], J. Ferguson[2], G. Kruger[3]; [1]Mississippi State University, Starkville, MS, [2]Mississippi State University, Mississippi State, MS, [3]University of Nebraska-Lincoln, North Platte, NE (332)

ABSTRACT

Previous research has suggested that a proportional carrier volume with a herbicide solution concentration similar to the concentration of a full-labeled rate better represents plant response to sublethal herbicide rates in simulated drift studies. However, due to soybean's extremely high sensitivity to dicamba, achieving a proportional carrier volume to doses that cause low levels of injury or yield is almost impossible with standard equipment. Therefore, field experiments were conducted across three sites in Mississippi in 2018 to evaluate the effect of carrier volume and spray quality on non-dicamba-resistant soybean response to a sublethal dicamba dose under field conditions. Dicamba plus glyphosate were applied at 1% of the standard use-rate to soybean at the R1 growth stage with a pulse-width-modulation (PWM) sprayer calibrated to deliver 140, 105, 70, 35, 14, and 7 L ha^{-1} (LPH) using either Fine or Coarse spray qualities. Significant effects of spray quality were not detected for soybean injury or plant height evaluations; however, carrier volume profoundly affected these parameters. Soybean injury 3 days after treatment (DAT) from carrier volumes of 70 to 140 LPH ranged from 6 to 16%; however, treatments applied at 7 or 14 LPH resulted in 49 and 42% injury, respectively. By 28 DAT, soybean injury ranged from 38 to 56% with higher injury resulting from reduced carrier volumes. Soybean height 28 DAT was similar amongst carrier volumes of 35 to 140 LPH (39 to 42% reduction); however, when carrier volume was reduced to 14 or 7 LPH soybean height was reduced 46 and 51%, respectively. Both the main effects of spray quality and carrier volume influenced soybean grain yield. Averaged across carrier volumes, Fine and Coarse spray qualities resulted in 30 and 26% yield loss, respectively. Likewise, yield loss ranged from 41 to 14% and increased as carrier volume decreased. Consequently, these data indicate that carrier volume can severely influence results in studies investigating sublethal dose exposure to soybean. These data demonstrate that with some active ingredients, a rate titration applied at the same delivery volume may not be the same as what may happen with true OTM such as particle drift. That is not to say that existing studies are not valid but instead that they may be more reflective of effects from contaminated spray equipment than from particle drift.

ENGENIA HERBICIDE RESEARCH UPDATE. C. Asmus*[1], S. K. Bangarwa[2]; [1]BASF, Raleigh, NC, [2]BASF Corporation, Durham, NC (333)

ABSTRACT

DICAMBA FINDINGS IN 2018. J. K. Norsworthy*[1], T. Barber[2]; [1]University of Arkansas, Fayetteville, AR, [2]University of Arkansas, Lonoke, AR (334)

ABSTRACT

Similar to observations from 2017, the off-target movement of dicamba in 2018 continued to be problematic for many growers across some areas of the U.S. where the Xtend technology was heavily adopted and acres were treated with dicamba in warmer spring and summer months. Research efforts in 2018 focused on better understanding dicamba volatilization and ways to possibly mitigate off-target movement in subsequent growing seasons. First, a large scale dicamba drift trial was conducted in Proctor, AR, in July in collaboration with Monsanto, now Bayer CropScience. Xtend soybean was planted on 15.6 ha (38.5 acres) surrounded by 81.8 ha (202 acres) of Roundup Ready (non-Xtend) soybean. The Xtend soybean was treated with a labeled rate of dicamba (XtendiMax with VaporGrip), glyphosate (Roundup PowerMax II), acetochlor (Warrant), and a drift retardant (Intact) at the R1 stage of soybean. Non-Xtend soybean plants on all four sides of the dicamba treated field were covered with plastic for up to 30 minutes after application. Injury to these plants from dicamba was comparable for covered and non-covered plants. Additionally, non-Xtend soybean plants were covered with 19-L buckets for 30 minutes following application every 15.2 m (50 ft) until the edge of the field along three transects. Plants beneath and adjacent to the buckets also showed similar levels of injury. Furthermore, wind during application was predominantly from the westward direction, yet 5% or more injury was observed on 24 ha (59.2 acres) outside the treated area with damage on all sides of the field. These findings led to the conclusion that volatility of Xtendimax with VaporGrip following a commercial application was a major contributor to the injury observed at this site. In other low tunnel volatility and large field research, volatility of dicamba increased with the addition of glyphosate (Roundup PowerMax II). Furthermore, it was found that dicamba volatilizes for at least four days during the spring and summer months unless a rainfall event occurs, at which time volatility ceases almost immediately. Additionally, it was observed in two separate trails that dicamba injury to soybean as a result of secondary movement in water from a treated field can occur, even when the first irrigation or rainfall event is at least nine days following application. Another takeaway was that volatilization of Xtendimax was greater from a canopy of XtendFlex cotton than when the herbicide was applied to baresoil. Efforts are also underway to establish a relationship dicamba acid air concentration and symptomology in soybean. Based on overall research conducted thus far, the newer formulations of dicamba must be applied early in the growing season to minimize risk for volatilization. In southern states where soybean is planted over an extended period, a date or temperature cutoff will most likely be needed or efforts to reduce large acreage sprays implemented if landscape damage is to be prevented. Using seven field trials conducted in 2017 and 2018, it was shown every hectare of treated with a new formulation of dicamba is likely to injure 1.5 ha of sensitive soybean. Furthermore, glyphosate may need to be removed as an allowable tank-mix with the new formulations if the goal is to minimize injury to nearby vegetation and to have a product that can be effectively used by applicators.

THE EFFECT OF TANK MIX PARTNERS ON XTENDIMAX VOLATILITY. M. Bernards[1], A. S. Culpepper[2], G. Kruger[3], S. A. Nolte[4], J. K. Norsworthy[5], D. de Oliveira Latorre[6], D. B. Reynolds*[7], P. Sikkema[8], B. Sperry[9], C. Sprague[10], D. O. Stephenson[11], R. Werle[12], B. G. Young[13]; [1]Western Illinois University, Macomb, IL, [2]University of Georgia, Tifton, GA, [3]University of Nebraska-Lincoln, North Platte, NE, [4]Texas A&M AgriLife Extension, College Station, TX, [5]University of Arkansas, Fayetteville, AR, [6]University of Nebraska, Lincoln, NE, [7]Mississippi State University, Mississippi State, MS, [8]University of Guelph, Ridgetown, ON, [9]Mississippi State University, Starkville, MS, [10]Michigan State University, East Lansing, MI, [11]Louisiana State University AgCenter, Alexandria, LA, [12]University of Wisconsin-Madison, Madison, WI, [13]Purdue University, Brookston, IN (335)

ABSTRACT

USE OF FIELD EVALUATIONS TO BETTER UNDERSTAND DICAMBA VOLATILITY. C. Brabham*[1], J. K. Norsworthy[1], M. Zaccaro[1], V. K. Varanasi[1], T. Mueller[2]; [1]University of Arkansas, Fayetteville, AR, [2]University of Tennessee, Knoxville, TN (336)

ABSTRACT

Nine field trials were conducted during the 2018 growing season to quantify off-target movement of dicamba using air samplers and greenhouse-grown dicamba sensitive soybean. The aim of our research was to better understand how environmental factors promote or lessen dicamba volatility and to correlate the amount of dicamba volatility captured (ng/m^3/day) to soybean injury using the Behrens and Lueschen scale. Briefly, dicamba (XtendiMax) at 560 g ae ha^{-1}, glyphosate (Roundup PowerMax II) at 860 g ae ha^{-1}, and the drift retardant Intact at 1% v/v were applied using a high-clearance sprayer to a 0.37 ha plot. At 30 to 60 min after application, three high flow (6.5 L/min) air samplers were placed centrally in the treated area. Every 24 hrs after application (24, 48, 72, and 96), the filter paper and puffs from air samplers were collected and replaced with new ones. Only data from filter paper have been measured and will be presented. Greenhouse-grown dicamba sensitive soybean were used as bio-indicators and these plants remained in the field for the following periods: 0.5 – 24, 0.5 – 48, 0.5 – 72, 0.5 – 96, 24 – 48, 48 – 72, and 72 – 96 hours after application. Soybean were rated for injury at 14 and 21 days after treatment with height and dry weight also taken at 21 days after treatment. As much as 27 ng/m^3/ day of dicamba acid was detected and generally the concentration decreased over time. In five of nine experiments, dicamba volatility was detected at 96 hrs after treatment. In four of nine experiments, a rain event occurred (0.35 to 1.4 cm) after application, and in these experiments, dicamba volatility ceased or was less than 1 ng/m^3/day. Soybean typically showed dicamba symptomology any time the dicamba acid was detected with air samplers, even at concentrations below 1 ng/m^3/day.

THE PROBLEM WITH RESOURCE DEPENDENT PLANT COMPETITION. C. J. Swanton*, S. Amirsadeghi; University of Guelph, Guelph, ON (337)

ABSTRACT

Resource-dependent plant competition has been studied for decades, but yet remains poorly understood. In this presentation, competition is defined as the capture of essential resources from a common finite pool by neighboring individuals. Inherently, this definition implies that competition is a process and that direct measurements of resource capture are necessary. To date, most studies have failed to account for both process and direct measurement, relying primarily on descriptive measurements of biomass and fitness. In addition, resource-dependent competition does not explain crop yield losses caused by the presence of early emerging weeds. In order to advance our understanding of the primary mechanisms of plant competition, the interface between resource dependent and resource independent plant competition will be presented.

ARTIFICIAL AND SURROGATE WEEDS FOR PHYSICAL WEED CONTROL RESEARCH. E. Gallandt*[1], L. Pedrosa[2]; [1]University of Maine, Orono, ME, [2]Federal University of Mato Grosso, Sinip, MT, Brazil (338)

ABSTRACT

Physical weed control (PWC) remains a foundational management practice in organic farming systems and could be increasingly important for control of herbicide resistant weeds. Low and variable efficacy of PWC tools is a recognized limitation, reflecting the main and interacting effects of tool design and adjustment, weed and crop species and size, and soil conditions. Artificial and surrogate weeds would be valuable tools for mechanistic study of tools, plants and soils, offering a high level of control for one variable and opportunity for higher throughput study of other variables. Greenhouse experiments conducted with an artificial weed, comprised of copper wire "roots" and a plastic aquarium plant "shoot," and small wooden golf tees were compared to commonly used surrogate weeds, canola and condiment mustard. Using a rake designed to mimic the action of a tractor-mounted tine-harrow, the artificial and surrogate weeds responded similarly to increasing levels of cultivation intensity. Seedling growth and anchorage force analyses will help to rationally design artificial weeds that better mimic important agronomic species.

INFLUENCE OF MANAGEMENT PRACTICES ON PALMER AMARANTH EMERGENCE PATTERN IN SOUTH CENTRAL NEBRASKA. P. Chahal*, E. R. Barnes, A. J. Jhala; University of Nebraska-Lincoln, Lincoln, NE (339)

ABSTRACT

The adoption of weed management strategies that rely on single site of action POST herbicides in the last two decades has resulted in the evolution of herbicide-resistant (HR) weeds. Tillage and PRE herbicides need to be integrated in weed management programs to effectively control HR weeds and to reduce the evolution of new HR weeds. Palmer amaranth has an extended period of emergence and the effect of shallow tillage at different timings on its emergence pattern has not been studied. Therefore, a field study was conducted in 2015 and 2016 on a grower's farm near Shickley in Fillmore County, south-central Nebraska to compare the effect of tillage timings and PRE residual herbicides on emergence pattern of Palmer amaranth. Treatments consisted of three tillage timings (early, mid, and late), three PRE herbicides, and a nontreated control arranged in a randomized complete block design with three replications. The Soil Temperature Model (STM^2) software was used to estimate soil temperature at 1 and 2 cm. The Weibull function was fit to total Palmer amaranth emergence (%) with day of year (DOY) and thermal time, with base temperature ranging from 7 to 25 C, as independent variables. There was an interaction between tillage/PRE treatments and year for total Palmer amaranth emergence and the emergence pattern. Total emergence was similar (7 to 128 plants m^{-2}) among nontreated, PRE herbicides and tillage timings in 2015. In 2016, early tillage had the highest total emergence of 1,674 plants m^{-2} followed by 869 plants m^{-2} with late tillage, and 533 plants m^{-2} with mid tillage, which was similar to 269 plants m^{-2} in nontreated control. All three PRE herbicides resulted in the least total Palmer amaranth emergence ranging from 49 to 88 plants m^{-2}. In 2015, mid and late tillage, and mesotrione/atrazine/*s*-metolachlor/bicyclopyrone and flumioxazin/chlorimuron resulted in a delayed emergence pattern compared with nontreated control. Similar to 2015, mid and late tillage in 2016 resulted in a delayed emergence pattern. According to the corrected information-theoretic model comparison criterion (AICc), the Weibull function using thermal time, calculated with a base temperature of 11 C, best explained the nontreated emergence pattern over two years. The results indicate that tillage at a depth of 10-cm has a variable effect on the total Palmer amaranth emergence and the emergence pattern compared with PRE residual herbicides. Therefore, a strong PRE herbicide is the key for reducing Palmer amaranth emergence when combined with a POST application to control late emerging plants.

WEED SYNDROMES AS CULTURAL PHENOMENA. J. Cardina*; Ohio State University, Wooster, OH (340)

ABSTRACT

Weeds are of human origin. The very notion of 'weed' is a social construct. Weeds differ from closely related species not in specific traits, but in the interplay of traits with human-modified environments, as they change over time. Agricultural weeds evolved in association with crop domestication under forces of agrestal selection, i.e. in a human-modified environment. As a result, weeds differ from non-weeds by their unique historical connection with human activity. This connection has helped give rise to changes in the dominance of troublesome species and is exhibited in problems such as species shifts and herbicide resistance. Given the large contribution of human activity to the development of these problems, it is unlikely that resolution will come from modifications of chemical or other technologies without corresponding changes in cultural practices. Moreover, technology modifications will likely contribute to future weed problems, unless the cultural context is also modified by understanding, changing, and motivating human behavior. This modification could include reducing the over-reliance on particular technologies, which is currently constrained by social and economic forces. Ongoing social debates about food quality, genetically modified organisms, organic farming, no-till agriculture, and emerging issues like gene drives are all associated in some way with weeds and their intersection with humans. Those who study and understand the biological dimension of weeds will influence these debates by connecting to the cultural component of what makes a plant a weed at a given time and place in response to human behavior.

GENOMICS FOR WEED SCIENCE: DE NOVO ASSEMBLY, ANNOTATION, AND FIRST ANALYSIS OF AN INVASIVE AND TROUBLESOME WEED. A. Porri*[1], J. Lerchl[2], R. A. Aponte[3]; [1]BASF SE, Ludwigshafen am Rhein, Germany, [2]BASF SE, Limburgerhof, Germany, [3], Ludwigshafen, Germany (341)

ABSTRACT

Palmer Amaranth (*Amaranthus palmeri*) is one of the most troublesome broadleaf weeds in southeastern USA. This weed species has become a major threat for the agricultural production since several populations have evolved resistance to different herbicide modes of action. Knowledge about the biology of this weed species has been helping weed scientists better manage *A. palmeri*. Information about the genome of *A. palmeri* would further allow weed scientists to better understand traits related to the weediness and resistance mechanisms of this species. Therefore, we performed sequence-based genotyping on six *A. palmeri* accessions from the USA, producing 6,990 polymorphism (SNP) markers in 2,108 genomic loci. Principal component analysis was employed to select the most representative *A. palmeri* line with the lowest heterozygosity level. Whole genome sequencing of the selected line was obtained via PacBio sequencing, yielding a total of 106 Gb, with half of the cumulative nucleotide count in reads equal or longer than 23.6 Kb. We *de novo* assembled and scaffolded the *A. palmeri* genome to a total assembly size of 650 Mb. This 650 Mb assembly size is slightly bigger than the estimated haploid genome, indicating that some heterozygous loci were separated during the assembly process. The N50 contig size is 2.6 Mb and the N50 scaffold size is 20.5 Mb. The 30 biggest scaffolds make up 90% of the total assembly size. Gene annotation suggested that some known major herbicide targets, including the *protoporphyrinogen oxidase 1* and *2* (*PPX-1* and *PPX-2*), are present in single gene copies. Protein sequence alignment revealed that PPX-1 and PPX-2 share low sequence similarity. Despite that, *in vitro* enzyme assays showed that PPX-1 and PPX-2 were inhibited by the same PPO herbicides. The *de novo* assembly and annotation of the *A. palmeri* genome can be used for comparative studies with other available genomes within the *Amaranthus* genus. Our results could also help on providing insight into the molecular basis of herbicide resistance in *Amaranthus* species.

QTL ANALYSIS OF SEED DORMANCY IN *JAPONICA*-LIKE WEEDY RICE. T. Imaizumi*[1], K. Ebana[1], Y. Kawahara[1], J. Hosoi[2]; [1]NARO, Tsukuba, Japan, [2]Nagano Prefecture Agricultural Experiment Station, Suzaka, Japan (342)

ABSTRACT

Weedy rice (Oryza sativa) is a de-domesticated form of cultivated rice that occurs in rice fields worldwide. Weedy rice has traits phenotypically distinct from those of cultivated rice such as high seed shattering, a black hull, the presence of an awn, greater height, and deep seed dormancy, although some weedy rice forms share many phenotypic traits with cultivated rice. Among its weedy traits, seed dormancy is a major factor for persistence of weedy rice. In weeds, seed dormancy strongly affects survival by controlling the timing of germination; it allows weedy rice to persist in the soil for a long time. In this study, we characterized the variation in seed dormancy in japonica-like weedy rice in Japan. We also generated whole-genome sequences for weedy rice strains and genotyped F2 populations from crosses of the Japanese rice cultivar Koshihikari and these strains by using the Genotyping by Random Amplicon Sequencing-Direct (GRAS-Di) technique. The whole-genome sequences indicate that the two major morphologically different strains of weedy rice found in Japan—straw-hull and black-hull strains—are genetically distinct. We also confirmed some variation in seed dormancy between them. Straw-hull strains generally had deeper seed dormancy than black-hull strains. Our quantitative trait locus (QTL) analysis of the F2 populations detected two QTLs increasing seed dormancy from Koshihikari × straw-hull weedy rice and one QTL decreasing seed dormancy from Koshihikari × black-hull weedy rice.

WHOLE-GENOME SEQUENCING PROVIDES INSIGHTS INTO WATERHEMP EVOLUTION. J. Kreiner[1], D. Giacomini[2], B. Waithaka[3], F. Bemm[3], C. Lanz[3], J. Hildebrandt[3], J. Regalado[3], P. Sikkema[4], P. Tranel*[5], D. Weigel[3], J. Stinchcombe[1], S. Wright[1]; [1]University of Toronto, Toronto, ON, [2]University of Illinois, Urbana, IL, [3]Max Planck Institute for Developmental Biology, Tubingen, Germany, [4]University of Guelph, Ridgetown, ON, [5]University of Illinois, Urbana, IL (343)

ABSTRACT

The recent appearance of agricultural and glyphosate-resistant waterhemp populations in Canada provides an opportunity to investigate evolutionary questions about the genetics of adaptation. In this study, we used a population genetics-based approach to examine the routes by which glyphosate resistance evolved in Canada waterhemp populations. We first assembled a high-quality reference waterhemp genome using 87x genome coverage of Pacific Biosciences long-read data from a single waterhemp plant. The reference genome contained 663 Mb assembled into 2,514 contigs with an N50 of 1.7 Mb. A chromosome-level assembly was obtained by scaffolding the contigs onto the *Amaranthus hypochondriacus* genome. Population genetics analysis was then performed using whole-genome resequencing data from 173 waterhemp plants sampled from agricultural field populations in the United States (Illinois and Missouri) and Canada (Ontario) as well as natural (non-weedy) populations in Ontario. The analyzed data supported the existing paradigm of two ancestral lineages, *A. tuberculatus* var. *rudis* and *A. tuberculatus* var. *tuberculatus*. More specifically, var. *rudis* was found in Missouri, var. *tuberculatus* was prevalent in the non-weedy Canada populations, and var. *rudis* was prevalent in Illinois, but with increasing admixture with var. *tuberculatus* in eastern Illinois populations. Of the two glyphosate-resistant agricultural Canada populations, one was predominantly var. *rudis* and likely arose via migration from a weedy U.S. population. The other glyphosate-resistant Canada population, however, was predominantly var. *tuberculatus* and was not highly differentiated from the non-weedy Canada populations. Consequently, it appears that glyphosate-resistant waterhemp in Canada arose both from migration of preadapted genotypes and from independent evolution within a native population. Across all populations, *EPSPS* amplification accounted for much of the glyphosate resistance, being found in 71% of all glyphosate-resistant individuals. Analysis of the *EPSPS* amplified region suggested a single origin of *EPSPS* amplification in the var. *tuberculatus* glyphosate-resistant Canada population, but multiple origins among all the other glyphosate-resistant populations. In summary, this research indicates glyphosate resistance in Canada waterhemp populations has evolved via two independent pathways, and the *EPSPS* amplification event has occurred multiple times within this species. Additionally, the genomic resources generated will be valuable for further research on the genetics and evolution of an extremely dynamic weed.

COMPARATIVE ANALYSIS OF GLYPHOSATE RESISTANT AND SENSITIVE GENOMES INDICATES GENOME REARRANGEMENT AS A MECHANISM OF ADAPTATION. E. L. Patterson*[1], W. Molin[2], D. G. Peterson[3], C. A. Saski[1]; [1]Clemson University, Clemson, SC, [2]USDA-ARS, Stoneville, MS, [3]Mississippi State

University, Mississippi State, MS (344)

ABSTRACT

Amaranthus palmeri (Palmer) is one of the most economically damaging weeds in the United States. Palmer has a wide geographic range, competes in a variety of cropping systems, and has several weedy traits that make it particularly aggressive. Palmer's dynamic genomic plasticity has endowed rapid adaption to several herbicide modes of action, including the molecule glyphosate. Genetic resistance to glyphosate is primarily conferred by way of a unique mechanism of gene duplication of the target enzyme 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS). The economic implications of glyphosate resistant Palmer and its unique mechanism of gene duplication, has become the focal point of several genetic and genomic studies. To establish a foundational genomic infrastructure to further understand the genomic and genetic architecture of rapid adaptation in Palmer, we constructed high-quality reference genome assemblies of two Palmer biotypes, one susceptible to glyphosate (GAS) and one with high levels of resistance to glyphosate (GAR). Our de novo genome assemblies of these two biotypes were performed with deep coverage single-molecule sequences (PacBio Sequel) and assembled with MeCat. The final GAS and GAR assemblies consisted of 646mb in 4,126 contigs (n50 = 310kb) and 666mb in 4,031 contigs (n50 = 289kb), respectively. Annotation and BUSCO analysis for GAS and GAR estimate genome completeness at 90.8% and 88.6%, respectively. The final assemblies, a genome-wide comparative analysis and survey of gene copy variation among sympatric pairs of glyphosate susceptible and resistant plants will be presented.

EXPLOITATION OF SEX FOR WEED MANAGEMENT. M. Matzrafi, S. Ohadi, M. B. Mesgaran*; University of California, Davis, Davis, CA (345)

ABSTRACT

We present the viability of a novel approach for managing weeds that exploits a demographic handicap inherited with a dioecious breeding system. Seed production in a dioecious population stringently depends on the co-occurrence and co-flowering of the two genders. Although under genetic control, sex expression in most dioecious plants can be labile and shift in response to the environment. Moreover, gender specialization in dioecious plants suggests that the same environmental cue can affect the growth and development of males and females differentially. We therefore hypothesized that seed production in a dioecious weed population can be reduce by skewing the sex ratio and/or increasing the flowering asynchrony between genders through the manipulation of their environment. Using Palmer amaranth (*Amaranthus palmeri*) as a model system, here we demonstrate, for the first time, that water stress can shift parental sex ratio and reduce flowering overlap (between the two sexes). Further studies are currently underway to decipher the genetic mechanisms underpinning sex determination and to quantify how a biased sex ratio and phenological isolation affect seed production in Palmer amaranth.

ADVANCES IN PRECISION WEED MANAGEMENT. V. Singh*[1], M. Bishop[1], D. Martin[2], M. Latheef[2], B. B. Sapkota[1], A. Filippi[1], M. V. Bagavathiannan[1]; [1]Texas A&M University, College Station, TX, [2]USDA-ARS, College Station, TX (346)

ABSTRACT

Sustainable crop yields needed to feed the increasing population would require innovative platforms for automation, precise data collection and analysis. The recent advances in Unmanned Aerial Systems (UAS) and sensor technologies have opened new opportunities for future agricultural systems. Weeds are the major pests of agricultural crops and biggest concern for sustainable yield production. The UAS derived image data have the potential to detect weeds and provide information on weed growth stages. Similarly, UAS-based spray applications can be performed for spot applications. Research conducted at Texas A&M University has indicated high success rate (95%) in identifying broadleaf species in soybean and cotton fields. The study conducted on UAS-based spray system highlighted that its use may increase the efficacy of contact herbicides as the air circulation due to rotors results in higher droplet density at abaxial surfaces of weed leaves. Preliminary studies on machine learning systems approach combined with herbicide sprayers and laser systems have indicated that these technologies may provide greater weed control efficiency and save herbicide costs. Artificial-intelligence based weed management tools will be helpful in minimizing herbicide-resistance issues in future.

ECOLOGICAL STRATEGIES TO MANAGE HERBICIDE-RESISTANT KOCHIA SEED BANK IN IRRIGATED CROPPING SYSTEMS OF THE US GREAT PLAINS. P. Jha*[1], A. Kniss[2], N. C. Lawrence[3], R. Yadav[1]; [1]Montana State University, Huntley, MT, [2]University of Wyoming, Laramie, WY, [3]University of Nebraska-Lincoln, Pullman, WA (347)

ABSTRACT

Stakeholders from across the northern and central Great Plains of the US have identified kochia (*Kochia scoparia*) as one of the most problematic and economically damaging summer annual weeds. This tumbleweed is currently a threat to sustainable crop production due to a near lack of effective herbicide options, especially in sugar beet-based crop rotations in this region. Widespread resistance to many different herbicides (including glyphosate, atrazine, ALS inhibitors, and dicamba) has increased the need for IWM-based solutions for managing this weed. For this multi-year (2017-2020) research conducted in Huntley, MT; Powell, WY; Lingle, WY; and Scottsbluff, NE; we propose: 1) quantifying temperature and moisture germination requirements of kochia accessions collected from the north-south transect (from Montana to Nebraska) and 2) using that information to evaluate the effectiveness of three ecologically-based IWM strategies, including stale seedbed, cover crop, and diversified crop rotations. Based on the germination temperature studies on 44 accessions collected from the three state region (MT-WY-NE), northern accessions (Huntley and Powell) tended to require fewer GDD to begin germination. Northern accessions tended to germinate for a much shorter period of time; that is, the germination period was much more compressed compared to the southern accessions (Lingle and Scottsbluff) which had a more extended germination period. Based on the water potential study, all accessions had the highest germination rate at Ψ of 0 MPa (no water stress), considered to be Ψ_0. The base water potential (Ψ_b) varied across accessions (–0.84 to –1.13 MPa). At the moderate water stress (–0.5 MPa), T_{50} values ranged from 0.5 to 1.6 days. However, at the high-level water stress (–1.2 MPa Ψ), kochia accessions from Huntley and Powell took only 4 to 6 days to achieve T_{50} compared with 14 to 25 days for Lingle and Scottsbluff accessions. This indicates that kochia from the north are well adapted to dry soil conditions and a more extended emergence of kochia can be expected under dry soil conditions in the southern locations. We will combine field-validated emergence data, hydrothermal time modeling, and climate data (2019-2020) to evaluate non-herbicidal weed control strategies (stale seedbed, cover crops, and diversified crop rotations) that have a high likelihood of reducing kochia seed bank and exposure of this species to herbicide treatments, thereby reducing selection for herbicide resistance evolution. Implementation and adoption of these ecologically-based IWM strategies will reduce potential environmental impacts associated with increased herbicide use, apart from mitigating herbicide resistance.

EARLY SEASON EXPOSURE TO WEED REFLECTED LIGHT HAS SEASON LONG IMPLICATIONS FOR SUGARBEET. A. T. Adjesiwor, A. Kniss*; University of Wyoming, Laramie, WY (348)

ABSTRACT

Experiments were conducted at the University of Wyoming in 2018 to evaluate the response of sugarbeet (*Beta vulgaris*) to timing of removal of weed-reflected light. A large-pail field study included a range of weed addition and removal timings to quantify sugarbeet growth parameters and yield. Kentucky bluegrass (used as a model-weed) was grown in a separate container from sugarbeet so there was no root interaction, and grass was clipped regularly to prevent direct shading of the sugarbeet plants. When weeds were present near sugarbeet between sugarbeet emergence until the two true-leaf stage, most sugarbeet growth and yield measurements were similar to sugarbeet grown surrounded by weeds for the duration of the season. For example, compared to the weed-free control treatment, season-long weed presence reduced sugarbeet root fresh weight by 32%, while removing weeds at the 2 true-leaf stage reduced sugarbeet root fresh weight by 33%. Similarly, sugarbeet leaf area was reduced 27% by both the season-long weedy treatment two true-leaf removal treatment. It appears that if sugarbeet is exposed to shade avoidance signals during emergence, substantial yield potential can be lost even if weeds are removed by the 2 true-leaf stage.

WEED COMMUNITY DYNAMICS AFFECTED BY LONG-TERM (36 YEARS) TILLAGE PRACTICES IN SOUTHEAST TEXAS. P. Govindasamy, D. Sarangi*, J. Mowrer, N. Rajan, T. Provin, F. M. Hons, M. V. Bagavathiannan; Texas A&M University, College Station, TX (349)

ABSTRACT

Changes in tillage practices can influence weed community dynamics, and consequently, the selection of appropriate weed management practices. Studies were conducted in 2016 and 2017 at Texas A&M University, College Station, TX to compare the impact of long-term (36 years) no-tillage (NT) and conventional tillage (CT) practices on weed community dynamics in grain sorghum and soybean. In sorghum, the number of weed species present in the NT system was twice as much as in the CT system; the Shannon-Wiener's index (*H*, P-value = 0.03) as well as species richness (*S*, P-value = < 0.01) were consistent with these findings. In the NT system, the majority of the weed seeds were located at the top 5 cm soil layer, which was 20 to 37% greater than that of the CT system. Johnsongrass [*Sorghum halepense* (L.) Pers.] and waterhemp [*Amaranthus tuberculatus* (Moq.) J. D. Sauer] were the two most dominant weed species in the long-term sorghum experiment, and the aboveground densities of these weeds were greater in the NT system compared to the CT system. A similar trend was also observed for the dominant weeds [waterhemp and prostrate spurge (*Euphorbia prostrata* Ait.)] in the long-term soybean experiment. In general, weed seedling emergence was delayed in the NT system, compared to the CT system, and the growing degree days required for 50% seedling emergence were higher in the NT system. Overall, findings from this 36-year long tillage experiment showed that the NT system had greater weed species diversity and density than that of the CT system and that the majority of the weed seeds were located on the top soil layer in the NT system. Growers transitioning from CT to NT system should be aware of the potential shifts in weed community dynamics and develop appropriate management programs.

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LOOKING FOR 'RARE' WEEDS OF AGRONOMIC CONCERN IN A CHANGING CLIMATE. S. K. Birthisel*[1], B. J. Brown[2], E. Gallandt[1]; [1]University of Maine, Orono, ME, [2]Cornell University, Geneva, NY (350)

ABSTRACT

Climate change may increase the spread of weeds and alter competitive relationships between endemic species. We hypothesized that some weeds currently 'rare' in Maine, USA might be at the northern end of their range, and thus potentially pre-adapted to future climatic conditions, posing an emerging risk to farm management. Through seedbank sampling (N = 30) and transect surveys (N =32) of Maine organic farms, we identified 88 weed species that are currently relatively 'rare' in Maine. We crossed referenced these data with records of weed species known to be especially abundant or troublesome in warmer regions of the USA, and identified 20 species of likely future agronomic risk. Principle coordinates analysis of transect survey data suggested that communities of 'rare' weeds were associated with latitude and vegetation height. For most species, too few individuals were observed to allow for species-level statistical analyses. However, logistic regressions of the relatively abundant 'rare' weeds *Persicaria maculosa* and *Panicum capillare* suggested that both of these species were significantly associated with more southerly latitudes in Maine. Overall, these results support the hypothesis that some currently 'rare' species in Maine are problematic in warmer regions of the USA, and may become more of a problem in our warming climate.

A WEED SEEDBANK SURVEY IN BIHAR AND EASTERN UP REVEALS VARIATIONS IN WHEAT WEED COMMUNITIES. C. J. Lowry*[1], D. C. Brainard[2], V. Kumar[3], R. Malik[4], R. Jat[5], S. Poonia[6], M. Singh[6], P. Kumar[7], A. Kumar[8], V. Kumar[9], R. K. Joon[8], A. McDonald[8]; [1]Agricultural Research Service, Urbana, IL, [2]Michigan State University, East Lansing, MI, [3]IRRI, Manila, Philippines, [4]CIMMYT-CSISA Hub, Patna, India, [5]CIMMYT, Delhi, India, [6]CIMMYT, Patna, India, [7]CIMMYT, Samastipur, India, [8]CIMMYT, New Delhi, India, [9]IRRI, New Delhi, India (351)

ABSTRACT

Weeds represent a major constraint to production of wheat in northern India. However, relatively little information is available on which species are dominant in the region, and how weed communities vary based on management history. The objectives of this study were to 1) characterize the composition of the weed seedbank from 84 farmer fields differing in tillage (conventional tillage [CT] versus zero tillage [ZT]) and terrain (Upland and Lowland) across three regions in Bihar and Eastern Uttar Pradesh: Samastipur-Vaishali-Muzaffarpur (SBM), Ara-Buxar (AB) and Maharajgunj-Kushinagar (MK), and 2) evaluate whether edaphic properties could explain variation in the weed communities. Within each region, we compared adjacent fields in which one field had been under ZT management in wheat for at least three previous seasons and the other was under CT. We collected soil samples following rice harvest but before wheat planting for the germinable seed bank assay, as well as for soil nutrient and texture analyses. The weed communities characterized from the soil seedbanks differed between the three regions sampled within this study, as well as between the upland and lowland terrain, but did not differ based on tillage regime. Common weeds characteristic of the AB region include *Rumex dentatus* and *Grangea maderaspatana*, weeds characteristic of the MB region include *Anagallis arvensis*, *Soliva anthemifolia*, and *Phalaris minor*; and weeds characteristic of the SVM region include *Chenopodium album*, *Mazus pumilus*, *Solanum nigrum*, *Physallis minima*, and *Amaranthus spinosus*. Weed species richness was greatest within the MK region, despite the SVM region containing varying upland and lowland systems. Variation in the weed seedbank community composition was partially explained by variation in edaphic variables. For example, soil pH, Fe, Mn, and percent silt were the soil variables found to explain the greatest amount of variation within the weed community. Despite a lack of effect of tillage on the weed community, we did find lower seedbank density of one major weed, *Phalaris minor*, in ZT compared to CT. Future research evaluating the economic importance of these species, and identifying pro-active strategies for managing them should be helpful for improving the productivity and sustainability of rice-wheat cropping systems in the region.

INCREASED TEMPERATURES AND ELEVATED CO_2 LEVELS REDUCE THE SENSITIVITY OF *CONYZA CANADENSIS* AND *CHENOPODIUM ALBUM* TO GLYPHOSATE. M. Matzrafi*[1], C. A. Brunharo[2], P. Tehranchian[3], B. Hanson[4], M. Jasieniuk[1]; [1]University of California, Davis, Davis, CA, [2]Oregon State University, Corvallis, OR, [3]University of Arkansas, Davis, CA, [4]University of California, Davis, Winters, CA (352)

ABSTRACT

Weeds cause significant crop yield and economic losses in agriculture. Treatment with herbicides is the most effective means of controlling weeds. Herbicide efficacy is strongly associated with environmental conditions at the time of application. In recent years, we have witnessed an increase in extreme weather events and, at the same time, an increase in reports on reduced herbicide sensitivity under unfavorable environmental conditions. In our study, two annual weed species, *Conyza canadensis* (horseweed) and *Chenopodium album* (common lambsquarters), were tested for both their response to glyphosate under different environmental conditions. Plants were treated with glyphosate (867 g ae ha^{-1}) and grown under different temperature regimes [control (18/12°C, day/night) and future predicted maximum temperatures (32/26°C)] combined with two CO_2 levels [ambient (400 ppm) and enriched CO_2 levels (720 ppm)]. Reduced glyphosate sensitivity was found in both species in response to elevated temperatures, enriched CO_2 levels, and the combination of both treatments. Moreover, loss of apical dominance and early initiation of reproductive structures were observed in glyphosate-treated plants grown under high temperature combined with elevated CO_2 level. Glyphosate translocation was also examined using ^{14}C-glyphosate. In plants that were subjected to the enriched CO_2 environment combined with the high temperatures, glyphosate was rapidly translocated out of the treated leaf to shoot meristems and roots compared with plants grown under control conditions. These results suggest that altered glyphosate translocation and tissue-specific sequestration may be the basis of reduced plant sensitivity. Therefore, overreliance on glyphosate for weed control under changing climatic conditions may result in more weed control failures.

A META-ANALYSIS OF ALTERNATIVE WEED HOSTS FOR PLANT PATHOGENS IN THE NORTH CENTRAL UNITED STATES. E. Burns*; Michigan State University, East Lansing, MI (353)

ABSTRACT

Weeds play a large role in plant disease frequency and spread. Specifically weeds can serve as alternative hosts for pathogens or their vectors. The efficacy of an integrated pathogen management program is modified by the extent weeds contribute to the reestablishment of plant diseases. Therefore, this met-analysis sought to answer the following questions: 1) do weeds serve as alternative hosts to plant pathogens common to the North Central region of the United States, 2) is there a relationship between crop and alternative weed host taxonomy, and 3) are alternative weed hosts more prevalent in soil or foliar borne diseases. To answer these questions a meta-analysis was conducted. Studies that are included in this meta-analysis were identified through keyword searches in the Web of Science database and restricted to articles published in academic journals. Concrete keywords used were (an asterisk is a replacement for any ending of the respective term; quotation marks indicate that the term was used as a whole, not each word alone): "weed host*" and pathogen* returning 1,220 papers. From this initial search studies had to fulfill the following criteria to be included: 1) conducted in the North Central region of the United States, 2) restricted to agronomic row crops, and 3) demonstrated transmission of the disease from the weed host to the crop. In total, 103 papers met this criteria. Overall, 97 weed species were identified as alternative hosts for plant pathogens in four crop families: Chenopodiaceae, Fabaceae, Poaceae, and Solanaceae. Interestingly 55% of studies were in the solanaceous crop potato. As hypothesized, there was a strong relationship between crop and weed host taxonomy. For Chenopodiaceae, Fabaceae, Poaceae, and Solanaceae crop families, 50, 10, 57, and 44% of identified weed hosts were in the same family. There was no relationship between weed host and disease infection pathway with 53% foliar and 47% soil borne diseases. This meta-analysis demonstrates that a diversity of weeds serve as alternative hosts for a variety of pathogens in the North Central region of the United States. Lack of alternative host weed control may lead to further spread of plant pathogens. Knowledge gained from this analysis will help inform integrated pest management plans for sustainable pathogen control.

INTERFERENCE OF *AMARANTHUS PALMERI* S. WATS. AND *DIGITARIA SANGUINALIS* (L.) SCOP. IN SOYBEAN. N. T. Basinger*[1], K. M. Jennings[2], D. Monks[2], W. Everman[2], D. Jordan[2], E. L. Hestir[3]; [1]University of Georgia, Athens, GA, [2]North Carolina State University, Raleigh, NC, [3]University of California, Merced, Merced, CA (354)

ABSTRACT

Field studies were conducted in 2016 and 2017 at Clinton, North Carolina to quantify large crabgrass [*Digitaria sanguinalis* (L.) Scop.] and Palmer amaranth (*Amaranthus palmeri* S. Wats.) intraspecific and interspecific interference in soybean. Weed density treatments consisted of 0, 1, 2, 4, 8 plants m^{-2} for Palmer amaranth and 0, 1, 2, 4, 16 plants m^{-2} for large crabgrass with (interspecific) and without (intraspecific) soybean. Soybean biomass was not affected by weed density. Weed biomass m^{-2} was fit to linear regression model for Palmer amaranth and large crabgrass grown with and without soybean. Weed biomass per m^{-2} increased with increasing weed density and was greater for Palmer amaranth and large crabgrass across treatment densities when not grown with soybean. Individual weed biomass for large crabgrass grown without soybean was greatest at the lowest density. Individual weed biomass was higher for all densities of Palmer amaranth not grown with soybean compared to weeds grown with soybean. When grown with soybean individual weed biomass for both weeds was not affected by weed density. Soybean yield loss estimates due to weed density were fit to a two-parameter rectangular hyperbola model. Predicted yield loss for soybean grown with Palmer amaranth ranged from 14% to 38% for densities 1 to 8 plants m^{-2} with a maximum yield loss estimate of 49%. Similarly, predicted loss for soybean grown with large crabgrass was 9% to 38% for densities 1 to 16 m^{-2} with a maximum yield loss estimate of 50%. Results from these studies indicate that Palmer amaranth is more competitive than large crabgrass at lower densities, but that similar yield loss can occur when high densities of either weed are present.

DORMANCY BEHAVIOR AND BIOLOGY OF AFRICAN MUSTARD WEED (*BRASSICA TOURNEFORTII*) IN AUSTRALIA. G. Mahajan*, B. S. Chauhan; The University of Queensland, Gatton, Australia (355)

ABSTRACT

Biology of *Brassica tournefortii* in the northern grain region of Australia.

Abstract

*Brassica tournefortii*Gouan. (African mustard)is an important winter broad leafweed, whichhas increased in prevalence in no-till cropping systems of the northern grain region of Australia. Experiments were undertaken to define the optimum conditions for its germination, emergence, and seed persistence; and to study its seed production potential. Highest seed germination (>87%) was found at an alternating day/night temperature of 25/15 Cwhen incubated under the dark environment. Light/Dark environment inhibited germination.Germination improved when seeds were incubated after treating with sodium hypochlorite for 10 min. Seed persistence was measured after incorporating seeds in nylon bags that were placed at 0 (surface), 2 and 10 cm depths in soil atthe Gatton research farm of The University of Queensland, Gatton. Seed persistence was low on the soil surface, with less than 10% of seeds remaining after 12 months.However, it increased with the increase in burial depth, with 20-40% of seeds remaining after 24 months at 10 cm.The seedlings emerged from the 0-2 cm during summer, autumn and winter seasons following rain.The seed production of this weed varied from 1000-12000 seeds plant^{-1}; however, seed production reduced enormously with water stress and in competition with wheat and chickpea crops. Thus, a reduced tillage and increased surface soil water with stubble retention may favour the proliferation of this weed throughout the year. These results suggest that diligent management without seed replenishment will greatly reduce this weed problem within a short period.

DEVELOPMENT OF A GOOSEGRASS (*ELEUSINE INDICA*) DRAFT GENOME AND APPLICATION TO WEED SCIENCE RESEARCH. H. Zhang*[1], J. S. McElroy[1], N. Hall[1], L. R. Goertzen[1], B. Bi[1], C. Charles[1], E. Peatman[1], E. K. Lowe[2]; [1]Auburn University, Auburn, AL, [2]Georgia Institute of Technology, Atlanta, GA (356)

ABSTRACT

Genomes are vital to the study of population genetics and evolution of species. To date, only one genome, barnyardgrass (*Echinochloa crus-galli*), of a C4 annual weedy grass species has been sequenced. Research was conducted to develop a draft genome of goosegrass (*Eleusine indica*; 2n = 2x = 18), one of the most common and troublesome weeds in the world. A draft assembly of approximately 492 Mb whole-genome sequence of goosegrass was obtained by de novo assembly of paired-end and mate-paired reads generated by Illumina sequencing of total genomic DNA. The genome was assembled into 24,072 scaffolds with N50 = 233,459 bp. More than 99% of transcriptome sequences were mapped to the goosegrass draft genome, and 95% of BUSCOs were present. The assembled genome contains 25,467 unique protein-coding genes. Genes associated with herbicide resistance were obtained and variant calling allowed the detection of 754,409 single nucleotide polymorphisms (SNPs). In addition, we also report 115,417 simple sequence repeats (SSRs) which can be deployed in population genetics and phylogenetic analysis. This is the first report of genome sequence of goosegrass. Our assembly was able to identify all major herbicide-resistance related genes and develop useful tool for other genomic and evolutionary analysis.

DETECTION OF RESISTANCE TO PPO-INHIBITING HERBICIDES USING THE SYNGENTA HERBICIDE RESISTANCE LEAF (HRL) TEST. S. S. Kaundun*[1], J. J. Downes[1], L. V. Jackson[1], R. Wuerffel[2], S. Hutchings[1]; [1]Syngenta, Bracknell, England, [2]Syngenta, Vero Beach, FL (357)

ABSTRACT

Resistance evolution to herbicides is reaching epidemic levels in a growing number of weeds and cropping systems worldwide due to lack of diversity in weed management practices. To limit the spread of resistance, new cases should be identified as quickly as possible and alternative weed control measures implemented. To date, herbicide resistance is still primarily confirmed using seeds collected from field survivors at the end of the growing season in the laborious and time-consuming whole-plant pot test. This is not always immediately possible due to seed dormancy and farmers being reluctant to allow resistant plants to grow to seed and contaminate the weed seed bank. Here we describe the Syngenta Herbicide Resistance Leaf (HRL) test which employs detached meristematic leaves for identifying herbicide resistance. The methodology is illustrated with the detection of resistance to PPO-inhibiting herbicides in *Amaranthus* spp.. Preliminary studies showed that individuals containing the 210 target-site codon deletion or mutations (R to G or M) at codon 128 in the PPX2L gene could be clearly distinguished from wild type sensitive plants. In the Syngenta HRL assay conducted in Petri-dishes or Falcon® tubes filled with informative rates of herbicides, resistance is manifested by green and healthy leaves as opposed to bleached and non-photosynthesizing tissues for sensitive plants 7-10 days after treatment. It has been successfully used for detecting resistance to PPO-inhibiting herbicides in field survivors from a number of US *Amaranthus tuberculatus/palmeri* populations tested locally or at a central location alongside known sensitive and resistant standards. The Syngenta HRL test has also proved effective for detecting resistance to some other fast-acting herbicides and weed species. Wherever applicable, it could constitute a very simple and cost-effective methodology for detecting herbicide resistance at its very onset by targeting the initial plant survivors in the field.

REGIONAL DIFFERENCES IN KOCHIA GERMINATION FROM THE US GREAT PLAINS: EFFECT OF WATER POTENTIAL. R. Yadav*[1], P. Jha[1], A. Kniss[2], N. C. Lawrence[3], G. Sbatella[4]; [1]Montana State University, Huntley, MT, [2]University of Wyoming, Laramie, WY, [3]University of Nebraska-Lincoln, Pullman, WA, [4]University of Wyoming, Powell, WY (358)

ABSTRACT

Development of multiple herbicide-resistant kochia across the central and northern US Great Plains is a serious concern. The problem is more serious in sugar beet-based crop rotations due to widespread occurrence of glyphosate and ALS-resistant kochia. These two herbicide chemistries are the only viable options for kochia control in sugar beet. Therefore, there is an immediate need to implement ecological weed management strategies. This requires improved understanding of germination characteristics of kochia. Experiments were conducted in 2017 at the MSU-SARC, Huntley, MT to quantify germination requirements of 44 kochia accessions collected from sugar beet fields in Huntley, MT; Powell, WY; Lingle, WY; and Scottsbluff, NE (North-South transect). To develop hydrotime models, eight water potential (Ψ) treatments from 0 to –1.2 MPa were used to determine the time taken for median germination (T_{50}), optimum water potential (Ψ_0), and base water potential (Ψ_b) for kochia accessions at 24 C using an event-time, 3-parameter log-logistic model. With a decrease in Ψ, the germination rate ($1/T_{50}$) for all accessions decreased. All accessions had the highest germination rate at Ψ of 0 MPa (no water stress), considered to be Ψ_0. At no- to moderate- level of water stress (0 to –0.5 MPa), kochia accession from all the locations achieved 50% germination in less than 2 days. However, at the highest level of water stress used in the study, T_{50} values for northern accessions ranged from 2 to 18 days compared with a maximum of 26 days for southern accessions, indicating that the northern accessions were more tolerant to water stress. These differences in moisture requirements possibly explain the regional differences in kochia germination patterns. The imposed dormancy of southern accessions under water deficit conditions can possibly be alleviated using a stale seed bed approach to stimulate germination and exhaust the kochia seed bank using tillage or a non-selective herbicide prior to late-planted crops such as dry bean grown in rotation with sugar beet.

TILLAGE AND COVER CROPS INFLUENCE WEED-INSECT INTERACTIONS IN WINTER SQUASH. D. C. Brainard*[1], M. M. Benzle[1], Z. Szendrei[1], L. R. Appenfeller[2]; [1]Michigan State University, East Lansing, MI, [2]Michigan State Univeristy, East Lansing, MI (359)

ABSTRACT

Reduced tillage strategies, including strip tillage (ST), may be helpful for improving soils and reducing crop stress, but often entail pest management tradeoffs. We hypothesized that manipulation of the quantity and spatial distribution of cover crop residue would help optimize soil and pest management objectives in organic, reduced tillage winter squash production. To test this hypothesis, a field trial was conducted to evaluate the impact of tillage (full width tillage [FWT] vs strip tillage [ST]), winter rye- hairy vetch (RV) cover crop planting arrangement (Mixed [RVM] vs segregated planting [RVS]), and mulch (none vs supplemental rye mulch [SRM]) on weeds, insects, soil N and yields of acorn squash. Four combinations of these factors were evaluated: 1) FWT/RVM; 2) ST/RVM; 3) ST/RVS; and 4) ST/RVS/SRM. In early September, rye and vetch seeds were drill-planted either in a standard full width mixture (RVM), or in segregated strips (RVS) consisting of 4 rows of rye alternated with 2 rows of vetch. In the FWT treatment (1), cover crops were mowed and incorporated with a chisel plow and field cultivator in early May. In ST treatments (2-4), cover crops were flail mowed in late May, and strip-tilled in early June, with strip tillage in RVS treatments restricted to the zone where vetch had been sown. In the SRM treatment (4), supplemental rye residue was added to the soil surface of the BR zone to attain approximately 8 T ha^{-1} dry residue. Acorn squash (*Cucurbita pepo*) was either direct seeded (2017) or transplanted (2018) into tilled strips and managed organically. Compared to standard grower practice (FWT/RVM), strip tillage (ST/RVM) resulted in: 1) greater abundance of persistent winter annual weeds (e.g. *Anthemis arvensis, Conyza canadensis*); 2) lower short-term soil N availability; 3) more striped cucumber beetles; 4) fewer aphids; 5) greater activity density of carabid beetles; and 6) no detectable impact on crop yield or quality. Within ST treatments, the RVS spatial arrangement had little effect on insects or N availability, but resulted in greater persistence of winter annual weeds, and lower yields in 1 of 2 years compared to RVM. Supplemental rye mulch (ST/RVS/SRM) improved weed suppression and yields compared to ST/RVS, and resulted in yields comparable to FWT/RVM. Overall, these results demonstrate complex shifts in weed and insect communities associated with strip tillage in acorn squash, and suggest that weed management constraints may be addressed in part through adjustments in cover crop management.

MULTIPLE RESISTANCE: THE REST OF THE STORY. D. Simpson*[1], M. Peterson[2], T. Wright[3]; [1]Corteva Agrisciences, Indianapolis, IN, [2]Dow AgroSciences, West Lafayette, IN, [3]Dow DuPont, Ag Division, Carmel, IN (360)

ABSTRACT

DIRECT SEEDED RICE IN SEQUENCE WITH NO-TILL WHEAT IN NORTH-WESTERN INDIA: WEED DYNAMICS, WEED MANAGEMENT AND EMERGING ISSUES. D. Yadav*[1], A. Yadav[2], R. Malik[3], G. Gill[4]; [1]CCS Haryana Agricultural University, Karnal, India, [2]CCS Haryana Agricultural University, Hisar, India, [3]CIMMYT-CSISA Hub, Patna, India, [4]University of Adelaide, Adelaide, Australia (361)

ABSTRACT

In north-western Indo-gangetic plains, direct deeded rice (DSR) has caught the attention as an alternate establishment method of rice due to reduced labor costs, and savings of water and energy. However, the field conditions under DSR are congenial for emergence of weeds due to absence of continuous flooding; hence weed management is quite challenging in DSR. A series of field experiments and farmer-participatory trials were undertaken in Haryana during the last decade (2006-07 to 2016-17) to understand and address some of the complex issues related to DSR, along with a survey on perception of farmers about DSR during 2012 and 2013. Initial weed dynamics studies indicated that there was a very quick shift in weed flora with change in establishment method from puddle transplanted rice (PTR) to DSR. *Echinochloa crus-galli* remained the dominant weed under PTR, whereas, other grass weeds like *Leptochloa chinensis*, *Eragrostis* spp, *Dactyloctenium aegyptium* and *Eleusine indica* which were minor weeds in PTR became major weeds in DSR. Infestation of sedges like *Cyperus rotundus* also increased under DSR. The prolonged period of weed emergence under DSR further added to the complexity of weed management. In long-term experiment continued at Karnal during 2010-11 to 2016-17, the infestation of grasses, broadleaf weeds and sedges increased under DSR than PTR. In zero-tillage wheat (ZTW), infestation of *Phalaris minor* (problematic weed in wheat in north-western India) was lowest when grown after no-till DSR than unpuddled DSR or PTR. However, *P. minor* was more in wheat grown after unpuddled DSR than PTR.

The technique of stale seedbed was found effective in reducing weed infestation and controlling volunteer rice plants in DSR. Inclusion of green cover crops of *Sesbania*, cowpea and mung bean helped in decreasing the weed infestation in DSR. Bispyribac-sodium 25 g/ha sprayed at 15-25 days after sowing (DAS) was quite effective against *Echinochloa crus-galli* and some broadleaf weeds (BLW) in DSR. Pre-emergence application of pendimethalin 1000 g/ha or pretilachlor + safener 500 g/ha or oxadiargyl 100 g/ha could be used to control other grass weeds such as *Dactyloctenium aegyptium*, *Leptochloa chinensis*, *Eragrostis* spp. and *Eleusine indica*. Pendimethalin was the best among these herbicides, but soil moisture was crucial for its better efficacy. Tank-mix of azimsulfuron 20 g/ha, pyrazosulfuron 25 g/ha, ethoxysulfuron 18.8 g/ha or metsulfuron + chlorimuron (ready-mix) 4 g/ha with bispyribac 25 g/ha also provided effective control of BLW and sedges along with *Echinochloa* spp. Fenoxaprop (with safener) 60 g/ha was found promising post-emergence herbicide against these grasses, but its tank-mix application with bispyribac had antagonistic effects. Cyhalofop-butyl could also be an early post-emergence option against these grasses. Need based one hand-weeding may be given to prevent seed production by weeds that escape herbicidal treatments. Survey in 2012-2013 also revealed higher infestation of grasses and sedges (98%) along with volunteer rice (10%) in DSR than PTR, which was consistent with the results of field experiments. In long-term field experiment at Karnal during 2010-11 to 2016-17, productivity of *basmati* rice under DSR was realized to be similar to PTR with lower cost of production. The DSR based rice-wheat system gave higher system productivity and net economic returns, primarily due to higher wheat productivity by 4-6 q/ha.

CHAFF LINING: A RECENTLY DEVELOPED LOW COST HARVEST WEED SEED CONTROL METHOD FOR AUSTRALIAN CROPPING SYSTEMS. J. C. Broster*[1], A. E. Rayner[2], A. Ruttledge[3], M. J. Walsh[4]; [1]Charles Sturt University, Wagga Wagga, Australia, [2]University of Sydney, Sydney, Australia, [3]Queensland Department of Agriculture and Fisheries, Toowoomba, Australia, [4]University of Sydney, Narrabri, Australia (362)

ABSTRACT

Harvest weed seed control (HWSC) involves the targeting of the weed seed bearing chaff fraction as it exits the combine. Several HWSC systems have been developed with proven efficacy on weed species that retain a large portion of their seed at crop maturity. The recently developed chaff lining and chaff tramlining practices concentrate the chaff fraction either directly behind the harvester or on wheel tracks. These simple, low cost approaches are being widely adopted in Australia. A series of pot trials were undertaken with the aim of determining the effect of chaff type and amount on weed seed survival when using chaff lining or chaff tramlining. These studies were conducted at three locations in 2018 and investigated the influence of increasing amounts of wheat chaff on rigid ryegrass (*Lolium rigidum*) emergence. Rates of chaff, equivalent to that produced during the harvest of wheat crops yielding 0.25, 0.5, 1.0, 1.5, 2.0, 2.5 and 3.5 t/ha were placed over rigid ryegrass seed on the surface of pots filled with potting mix. Increasing amounts of wheat chaff incrementally reduced rigid ryegrass emergence, with the highest chaff rate 42 t/ha (3.5 t/ha wheat yield equivalent) allowing only 19% emergence. The influence of barley, canola and lupin chaff type on rigid ryegrass emergence was examined in a similar pot study at one location. The different crop species also provided different rates of reduction in emergence, at a crop yield equivalent of 2.0 t/ha wheat reduced emergence by 45% compared with canola (30%), lupins (45%) and barley (54%). These results highlight that emergence of rigid ryegrass and, therefore the efficacy of chaff lining is reliant on the concentration of high amounts of chaff and the type of chaff.

WEEDS AS INDICATORS OF SOIL IMBALANCE AND OTHER RURAL LEGENDS. D. Doohan*[1], M. Kleinhenz[2], C. Brock[2], D. Jackson-Smith[2], S. Culman[3], S. Kumarappan[2], C. Herms[2], A. Levia Soto[2]; [1]Ohio State University, Wooser, OH, [2]Ohio State University, Wooster, OH, [3]Ohio State University, wooster, OH (363)

ABSTRACT

Soil balancing is an alternative approach to soil management that has its origin in the base cation saturation ratio (BCSR) hypothesis. BCSR was first proposed by Lowe more than 100 years ago, and proposes an 'ideal soil' for plant growth with balanced saturations of Ca (65-80%), Mg (6-12%), and K (1-5%). Many Midwest soil laboratories and consulting groups have and continue to use the BCSR concept in formulating soil management recommendations, impacting several hundred thousand acres of grain crops in Ohio alone. The practice is most closely associated with the late Professor William Albrect of University of Missouri, and with ACRES USA, an organization that provides annual conferences and educational materials for the sustainable farming community. Soil balancing has never been accepted within the community of land grant universities. Recent interviews with organic farmers in the Midwest, an historically underserved population, indicate large percentages assenting to belief and practice in soil balancing, including the belief that weeds diminish in balanced soils. Our team, supported by the USDA OAREI program, has challenged the land grant paradigm of skepticism for unsanctioned practices by engaging with soil balancing organic farmers and consultants to undertake development of a shared knowledge around the subject. We have established large scale experiments at four research station sites and completed collaborative experiments on about 20 organic farms. During 2018 we surveyed 859 organic corn growersfrom Ohio, Michigan, and Illinois and interviewed 33 additional farmers and consultants. Results provided additional substantiation of the broad support for soil balancing in the organic farming community, and how Albrect's focus on cation ratios has evolved to one integrating mineral amendments, cover crops, micronutrients, and biostimulants. The team continues to engage with a multi-state community of farmers through a website, webinars, telephone call-ins, andspeaking opportunities. Preliminary experimental results point towards improvements in tilth and declining annual grass populations as soils become increasingly balanced. These results provide the first experimental data supporting soil balancing but they also suggest strongly that cation balancing is likely not appropriate for all soils, especially low CEC sands.

EFFECTS OF DAY AND NIGHT APPLICATION OF GLUFOSINATE ON AMMONIA ACCUMULATION, ELECTRON TRANSPORT RATE, AND WEED CONTROL. E. B. De Castro*[1], C. A. Carbonari[2], F. H. Krenchinski[3], E. D. Velini[3], M. F. Dias[3], T. Tseng[4]; [1]Mississippi State University, STARKVILLE, MS, [2]Sao Paulo State University, Botucatu, Brazil, [3]Sao Paulo State University, BOTUCATU, Brazil, [4]Mississippi State University, Mississippi State, MS (364)

ABSTRACT

Glufosinate is a non-selective herbicide applied post-emergence with a broad spectrum of weed control that can be used as a viable alternative mode of action in crop production. Research was conducted to evaluate the effects of day and night time application of glufosinate on ammonia accumulation, electron transport rates (ETR), and control of *Digitaria insularis*, *Lolium multiflorum*, and *Eleusine indica*. The treatments consisted of six rates of glufosinate herbicide (0, 150, 300, 600, 1200, and 2400 g a.i. ha^{-1}) and two application timings (7:30 am and 7:30 pm). The variables evaluated included ammonia accumulation, ETR, visual injury, and dry mass. The data were subject to analysis of variance ($\alpha = 0.05$). Ammonia concentration was determined by Mitscherlich nonlinear model, using PROC NLIN SAS (version 9.4). ETR data were analysed by deviance analysis, with a generalized linear model of the quasibinomial type. The control analysis was performed by confidence interval with *t* test established at 10% probability. Dry mass was analyzed with bayesian models using the Markov Chain Monte Carlo (MCMC) within R2Openbugs.

When compared to the non-treated check, glufosinate (2400 g ha^{-1}) application resulted in ammonia accumulation greater than 48 and 51 times in *D. insularis*, 65 and 79 times in *L. multiflorum*, and 116 and 18 times in *E. indica* in applications at 7:30 a.m. and 7:30 pm, respectively. ETR were reduced rapidly when applications were performed at 7:30 am; when evaluated 12 hours after application (HAA), ETR reduction was lower when applications were performed at 7:30 pm. However, 24 HAA, the results were similar, regardless of the treatment timing. Glufosinate application provided effective weed control at 300 g ha^{-1}, resulting in dry mass reduction of all evaluated species. The ammonia accumulation was inversely proportional to the ETR; thus, ETR has the potential to characterize glutamine synthetase inhibition. The day and night time application of glufosinate presented efficient control, regardless of the treatment timing. These results suggest that day and night time application can be used to control *D. insularis*, *L. multiflorum*, and *E. indica* in early stage. This research also indicates that that the use of ETR is an effective means of evaluating glufosinate injury.

INTEGRATING CULTURAL PRACTICES AND HERBICIDES FOR MANAGING GLYPHOSATE-RESISTANT PALMER AMARANTH IN SORGHUM. R. Liu*[1], V. Kumar[1], R. Perumal[2], T. Lambert[2]; [1]Kansas State University, Hays, KS, [2]Kansas State University, hays, KS (365)

ABSTRACT

Glyphosate-resistant (GR) Palmer amaranth (*Amaranthus palmeri*) has become a major challenge for successful production of grain sorghum in the Central Great Plains, including Kansas. Due to limited herbicide options, integrated weed management practices are urgently needed for controlling GR Palmer amaranth in grain sorghum. In this context, a field study was initiated at Kansas State University Agricultural Research Center (KSU-ARC) in Hays, KS in 2018, to determine the effect of sorghum hybrid, row spacing and herbicide programs on GR Palmer amaranth control, shoot dry weight reduction, and grain yield of sorghum. Treatments included two cold-tolerant grain sorghum hybrids: Pioneer 87P06 (commercial check) and ATx645/ARCH12012R (developed by KSU-ARC breeding program); row spacing of 38 (narrow) and 76 cm (standard); and three herbicide programs: (1) acetochlor at 1,890 g ha^{-1} plus atrazine at 938 g ha^{-1} PRE, (2) acetochlor at 1,890 g ha^{-1} plus atrazine at 938 g ha^{-1} PRE followed by (fb) bromoxynil at 230 g ha^{-1} plus pyrasulfotole at 40 g ha^{-1} POST, and (3) a nontreated weedy check. Experiment was performed in a randomized complete block design with factorial arrangement of treatments and 3 replications. The study was planted on April 17, 2018 in wheat stubble using a seeding rate of 172,149 seeds per hectare. Plots were uniformly infested with a GR Palmer amaranth population prior to sorghum planting. Data on density and percent visual control of GR Palmer amaranth were recorded at biweekly interval throughout the growing season. At physiological maturity, shoot dry weights of GR Palmer amaranth were determined from the center of each plot by using two 0.5 m^{-2} quadrats. Sorghum grain yield was also recorded at harvest. Results indicated that both PRE alone and PRE fb POST programs provided an excellent, season-long control (>97%) of GR Palmer amaranth. A sequential POST application of bromoxynil plus pyrasulfotole to PRE acetochlor plus atrazine treatment did not improve the GR Palmer amaranth control. In non-treated weedy plots, GR Palmer amaranth density was not affected by sorghum hybrid or narrower row spacing; however, its shoot dry weight was reduced by 37% with 38 compared to 76 cm rows. Sorghum grain yield of Pioneer 87P06 was increased by 27% in 38 compared to 76 cm rows; whereas, row spacing had no effect on grain yield of ATx645/ARCH12012R hybrid. In conclusion, the combination of narrow row spacing (38 cm) and PRE application of acetochlor plus atrazine can be utilized for effective and season-long control of GR Palmer amaranth in early-planted (cold-tolerant) grain sorghum production in this region.

CHENOPODIUM ALBUM RESISTANCE IN INDIA AND ITS MANAGEMENT STRATEGIES. S. Singh*; CCSHAU, Hisar, India (366)

ABSTRACT

Chenopodium album is the most ubiquitous weed of several continents infesting many crops and orchards. Greater occurrence and intensity of *C. album* was found in light soils in wheat fields in NW India where it competes more vigorously. It was very sensitive to several broadleaf wheat herbicides; however, complaints of poor efficacy was reported recently from many locations. Based on farmer's complaint of poor control of *C. album*, field and pot experiments were conducted during 2016-17 and 2017-18 to evaluate efficacy of 2, 4-D (amine and ester), metsulfuron-methyl, carfentrazone-ethyl, metsulfuron + carfentrazone (Readymix, RM), sulfosulfuron + metsulfuron (RM), mesosulfuron + iodosulfuron (RM), fenoxaprop + metribuzin (RM), metribuzin, clodinafop + metsulfuron/metribuzin (RM), halauxifen + fluroxypyr (RM), MCPA, pendimethalin and isoproturon. In case of pot studies, a susceptible population from University research farm was also used for comparisons. Spraying was done with the help of knapsack sprayer delivering 300 L water volume using flood-jet nozzle. Field plots were sprayed with recommended rates of herbicides, whereas in pots half, full and double of the recommended rates were used and compared with untreated plants with three replicates. Observations were recorded for visual mortality, weeds dry weight, and yield (in field trials). Data was analyzed using statistical software SPSS. Metsulfuron provided only 20% mortality of *C. album* under field conditions; similarly its RM formulation with sulfosulfuron, mesosulfuron + iodosulfuron, fenoxaprop + metribuzin, metribuzin alone and clodinafop + metsulfuron/metribuzin provided only 30-75 % control. Highest weed control efficiency was recorded with RM of metsulfuron + carfentrazone, pendimethalin, isoproturon, 2,4-D (Ester and amine) and MCPA, other herbicides were not effective. Under pot studies, metsulfuron provided complete mortality of susceptible population, whereas even double the recommended rates failed to control the resistant population from farmers' field. Similarly, sulfosulfuron + metsulfuron and mesosulfuron + iodosulfuron and clodinafop + metsulfuron/metribuzin were not found effective against the farmer's field population. This study confirms resistance in *C. album* to metsulfuron or its ready-mix formulations with sulfosulfuron/clodinafop and mesosulfuron + iodosulfuron. The ready-mix formulation of metsulfuron + carfentrazone may also have similar fate as delayed application of carfentrazone is less effective against several broadleaf weeds.

WEED IDENTIFICATION BY MOBILE DEVICE. H. J. Santel*, M. P. Schikora; BASF, Langenfeld, Germany (367)

ABSTRACT

An array of mobile device-based applications for field status monitoring, problem identification, and decision making on crop management is under development at BASF Digital Farming, including an identification system for most important weeds at young development stages typically found in major annual field crops. The user takes an image of the weed in question with a mobile device (e.g. smart phone) in the field. The application excises the core plant area of the photo and uploads this data to a host computer for further processing. There, image analysis is performed using deep residual neural networks. For a recognition of the characteristics of the weed, a multitude of evident morphological plant features including leaf shape, color scheme, surface structure and texture, edge to area ratio of leaves, but also less tangible features are examined. The algorithm compares such information with features learned from images used for its training on the range of possible appearances of individual plants of a given species. For the weed identification algorithm thousands of proprietary images from natural and controlled environments have served as a training resource of the possible appearances of weeds covering development stages from cotyledons to advanced stages. The accuracy of identification is influenced by several factors including size, quality and variety of the set of training images as well as the singularity of plant features depicted in the image of the weed in question. As an output the system proposes one or several species for which the algorithm has calculated high conformity with trained weed data. This result is transferred back to the user's device and can serve as input into pending decisions on crop management. Identification delivers very high precision of identification for weed species with a relatively unique appearance like *Abutilon theophrastii or Xanthium strumarium* ,and becomes more challenging within a genus like *Polygonum* with many similar looking species.

LIVING MULCH AS A TOOL FOR INTEGRATED WEED MANAGEMENT IN ORGANIC VEGETABLES. C. R. Hooks[1], A. W. Leslie[2], V. L. Yurchak*[1]; [1]University of Maryland, College Park, MD, [2]University of Maryland, Glenn Dale, MD (368)

ABSTRACT

Organic vegetable farmers rely on tillage and cultivation as tools to control weeds, which can increase production costs and negatively impact soil health. Growing organic vegetables under reduced tillage is made even more difficult because of a lack of effective and affordable herbicides labeled for organic use. Living mulches may be incorporated into integrated weed management programs to suppress weeds throughout the growing season, potentially allowing vegetable crops to be grown under reduced tillage. Here, we present data for a three-year project testing whether red clover (Trifolium pretense), used as a living mulch, can provide season-long suppression of weeds in a bell pepper (Capsicum annuum) crop. Our experiment tests the living mulch against dead, organic mulch from a fall-planted mixture of rye (Secale cereal) and crimson clover (Trifolium incarnatum) mulch. Data were collected on weed species and abundance, persistence on the different types of mulch, crop performance and yield quantity and quality. Our hypothesis is that the dead organic mulches will degrade over time, resulting in decreased weed suppression later in the season, while the red clover will continue to suppress weeds for the duration of the pepper crop. Results indicate greater weed suppression in the living mulch treatment throughout the growing seasons compared to the killed cover crop mulch, however better yields were seen in the conventionally tilled check treatment compared to both the living mulch and dead cover crop mulch treatments.

SPRING-SEEDED CEREAL RYE FOR WEED SUPPRESSION IN WATERMELON. K. M. Vollmer*[1], M. J. VanGessel[2], B. A. Scott[2], T. E. Besancon[3], B. L. Carr[4]; [1]University of Delaware, Delaware, VA, [2]University of Delaware, Georgetown, DE, [3]Rutgers University, CHATSWORTH, NJ, [4]Rutgers University, Chatsworth, NJ (369)

ABSTRACT

Weeds cause significant yield loss in watermelon production systems. Commercially acceptable weed control is difficult to achieve even with heavy reliance on herbicides. These herbicides often do not provide season-long weed control between plastic rows. In addition, several weed species have become resistant to commonly used herbicides. Cover crops have been adopted in many production systems to improve weed control. The objective of this study was to evaluate a spring-seeded cereal rye cover crop with PRE or POST-transplant herbicides for weed management between plastic mulch. The study was a two-factor factorial with main effects of cover crop termination timing and residual herbicide application timing. The study was conducted at three locations (DE in 2017; DE and NJ in 2018). Beds were formed and cereal rye (134 kg ha^{-1}) seeded 4 wk prior to watermelon transplanting. Cover crops were terminated 3 and 5 weeks after transplanting (WATrplt) in 2017, and 4 and 6 WATrplt in 2018 with clethodim (136 g ha^{-1}) plus a nonionic surfactant (0.25% v/v). Residual herbicide treatments were applied at transplanting and 2 WATrplt. Residual herbicides were halosulfuron (15 g ha^{-1}) plus *s*-metolachlor (1,346 g ha^{-1}). Cover crop biomass was collected prior to each termination date by removing four 0.25 m^2

quadrats from each plot then dried to a constant weight. Weed control was evaluated on a 0 to 100 scale every 2 wk until watermelon vines enveloped the center rows. Weed density was taken 0, 2, and 5 WATrplt in 2017 and 0, 2, and 6 WATrplt in 2018 using at least three 0.5 m^2 quadrats in each plot. Weed biomass was collected 5 WATrplt in 2017 and 6 WATrplt in 2018 using the same quadrats then dried to a constant weight.

Cereal rye biomass was similar at both the first and second termination timings. Halosulfuron plus *s*-metolachlor did not influence pigweed spp. or common lambsquarters density. However, plots containing cereal rye had lower pigweed spp. and common lambsquarters densities and biomasses compared to plots without cereal rye. The presence of cereal rye did not negatively influence marketable watermelon yield. These results demonstrate that a spring-seeded cereal rye cover crop can help to reduce weed density and biomass, and potentially enhance overall weed control. Cover cropping alone did not provide full-season weed control, so additional studies are needed on the best methods to integrate cover cropping with other weed control methods in watermelon.

EVALUATION OF FIELD PENNYCRESS AS A USEFUL OILSEED COVER CROP FOR SUPPRESSION OF WEEDS IN THE NORTHERN GREAT PLAINS. J. V. Anderson*[1], A. Nobriga[1], B. Bigger[1], M. Berhow[2], S. Vaughn[2]; [1]USDA-ARS, Edward T. Schafer Agricultural Research Center, Fargo, ND, [2]USDA-ARS, National Center for Agricultural Utilization Research, Peoria, IL (370)

ABSTRACT

A field study conducted in Fargo, ND, identified native populations of field pennycress as the most dominant species following winter. These native populations of field pennycress were allowed to develop to early maturity in two replicated field plots. The canopy cover, biomass, nutrient retention, oil quality, and allelopathic properties of field pennycress were assessed. The canopy cover of weeds remaining after removal of field pennycress from the field plots was also monitored to determine correlations between field pennycress cover and suppression of other weeds. Similar data was also collected from an adjacent alfalfa plot to determine the weed-suppressing performance of field pennycress to that of established alfalfa. Results for this study indicated a strong correlation (r^2=0.96) between overall field pennycress canopy cover and suppression of other weeds, similar to that observed for alfalfa. Field pennycress also had higher levels of macro- and micro-nutrients than alfalfa, oil quality traits suitable for bio-based applications, and allelopathic compounds with important bioactive properties. Blocks within field plots containing the least weed canopy cover correlated well with overall total mg of glucotropaeolin (r^2=0.68), benzoyl-substituted glucosinolate 1 (r^2=0.63), benzoyl-substituted glucosinolate 2 (r^2=0.41) and sinigrin (r^2=0.45). These results indicate that native populations of field pennycress have superior freezing tolerance, provide value added ecosystem services, and could have utility as a winter oilseed cover crop to develop double- or relay-cropping systems for agricultural intensification in northern climates.

MODIFY THE WHEAT ARCHITECTURE AS AN AGRO-TECHNICAL TOOL TO IMPROVE ITS COMPETITIVENESS WITH WEEDS IN AN INTEGRATED WEED MANAGEMENT (IWM). R. N. Lati*[1], Z. Peleg[2], R. Ben-David[3]; [1]Agricultural Research Organization, Newe Ya'ar Research Center, Kfar Tavor, Israel, [2]The R.H. Smith Institute of Plant Science & Genetics in Agriculture, Faculty of Agriculture, Food and Environment, The Hebrew University of Jerusalem, Rehovot, Israel, [3]Agricultural Research Organization, Bet Dagan, Israel (371)

ABSTRACT

REWARDING BEST PEST MANAGEMENT PRACTICES VIA REDUCED CROP INSURANCE PREMIUMS. H. J. Beckie*[1], S. J. Smyth[2], M. D. Owen[3], S. Gleim[2]; [1]University of Western Australia, Crawley, WA, Australia, [2]University of Saskatchewan, Saskatoon, SK, [3]Iowa State University, Ames, IA (372)

ABSTRACT

Despite decades of research, development, and extension on the mitigation and management of pesticide resistance, the global agricultural situation is becoming increasingly dire. Pest populations with evolved resistance to multiple pesticide sites of action are becoming the norm, with fewer remaining effective xenobiotics for control. We argue that financial incentives and not regulations are needed to encourage farmers or land managers to use best management practices recommended by academia. Although some incentives are offered by pesticide manufacturers or distributors, there is a paucity of incentives by other industry sectors and all levels of government (federal or state/ provincial). Crop insurance can be important to facilitate and reward best pest management practices and address other important agricultural policy objectives. In this presentation, we describe possible changes to crop insurance programs in the United States and Canada through premium rate changes to incentivise clients to adopt best management practices.

REMOTE DETECTION OF GOOSEGRASS IN TOMATO AND STRAWBERRY PLASTICULTURE PRODUCTION USING MACHINE VISION. S. M. Sharpe*[1], A. W. Schumann[1], N. Boyd[2]; [1]University of Florida, Wimauma, FL, [2]University of Florida, Balm, FL (373)

ABSTRACT

Florida vegetable and strawberry production primarily relies on fumigated, drip irrigated plasticulture systems. These systems result in weed infestations occurring primarily between the bedded rows and within planting holes in the plastic mulch. Reliable and cost-effective remote detection of weeds within the bed is an important technological step for smart-spraying and scouting applications. Thanks to recent technological development for graphical processing units, remote sensing using digital imagery and deep neural networks is a feasible option for agriculture. Object detecting convolutional neural networks permit localization within images while minimizing time investments during manual image processing during training. Object detection using bounding boxes for grasses is a difficult undertaking due to grass leaf morphology and the potential positions and angles it may occupy. Goosegrass is one of the most commonly encountered grassy weeds in Florida horticulture. The study objective was to test the feasibility of using small boxes (labels) to target smaller portions of the goosegrass leaf with two object detection convolutional neural networks to detect goosegrass growing within the bed in strawberry and tomato production. During testing (n=126), DetectNet leaf detection Fscore was 0.60, precision was 0.97, and recall was 0.43. For DetectNet plant detection, the Fscore was 0.80, precision was 0.75, and recall was 0.86. For leaf detection with tiny Yolo, the Fscore was 0.62, precision was 0.97, and recall was 0.46. For tiny Yolo plant detection, the Fscore was 0.83, precision 0.81, and recall 0.85. Overall, tiny Yolo outperformed DetectNet, with increased precision for very small goosegrass plants. Reductions in precision were primarily due to identification of other grass species leaf tips and nutsedge leaves as goosegrass. Overall, remote detection of goosegrass by training the neural network to detect narrow portions of the leaves appears a viable option. Future improvements will include network desensitization to nutsedges and expansion to additional vegetable cropping systems.

INDAZIFLAM SOIL DISSIPATION FROM GEORGIA PECAN GROVES. T. L. Grey*[1], K. M. Eason[2]; [1]University of Geogia, Tifton, GA, [2]University of Georgia, Tifton, GA (374)

ABSTRACT

Pecan production in the southeastern United States has increased due to the worldwide demand for the nuts of this tree. Information about the effects of the residual herbicides indaziflam and rimsulfuron on newly planted pecan trees was evaluated over time and dissipation from sandy loam soil. After winter pecan tree planting, spring herbicide applications were applied to pecan trees. Visual injury and soil samples were taken up to 10 times during the growing season. Regression analysis of treatments over 392 days after application indicated indaziflam half-life was up to 71 days while rimsulfuron was 1.5 days. This information will benefit growers seeking viable weed control options when establishing new groves to meet the increased worldwide demand for pecan nuts.

LINKING THE INVASION OF WEEDY SPECIES TO ALTERED FUNCTIONAL ADAPTATIONS OF SOIL MICROBES. K. Min*[1], N. Tharayil[1], P. C. Bhowmik[2], V. Suseela[1]; [1]Clemson University, Clemson, SC, [2]University of Massachusetts, Amherst, MA (375)

ABSTRACT

Non-native plant invasion alters ecosystem biogeochemical cycling via fast growth and great litter generation. Yet, we lack the knowledge how changes in the aboveground processes influence microbial activity in soil. Given that plant invasion is widespread across ecosystems and microbial activity feeds back to plant productivity, it is critical to understand microbially-driven soil organic dynamics under invasion. Here we quantified the Michaelis-Menten kinetics of four common enzymes (AP, acid phosphate; BG, beta-glucosidase; NAG, N-acetyl-glucosaminidase; PER, peroxidase) and corresponding substrate concentrations from Japanese Knotweed (*Polygonum cuspidatum*) invaded and non-invaded soils at 0-5, 5-10, and 10-15 cm. We hypothesized that (1) plant invasion will reduce the activity and production of AP, BG, and NAG, but increase the activity of production of PER, and that (2) invasion effects on enzyme activity will attenuate with soil depth. At top soils (0-5 cm), plant invasion increased the activity and production of all enzymes, except AP. In contrast, at deeper soils (5-10, 10-15 cm), invasion increased the activity of production of PER, but decreased the activity of production of BG and NAG. Organic phosphorus (substrate of AP) content did not vary under invasion. These results highlight that invasion preferentially increased microbial potential to break down recalcitrant carbon, implying enhanced vulnerability of relatively stable carbon under invasion. Also, our data suggest that the effects of plant invasion on microbial activities are not confined to surface, but penetrated into deeper soils. Future restoration efforts seem to consider reversing the vertically-modified soil organic matter decay dynamics as well as the aboveground vegetation changes.

INTRODUCTION TO THE SYMPOSIUM. P. C. Bhowmik*; University of Massachusetts, Amherst, MA (376)

ABSTRACT

Weed management is a science-based decision-making process that includes the knowledge of weed biology, environmental information, and available technology for weed control to maintain quality and productivity of turfgrass, ornamental and nursery crops. Many weeds pose inherent problems in production system of these special crops. The economic impact of these industries is enormous in the United States, providing $57.9 billion for turfgrass, including golf courses, $147.8 billion for ornamental horticulture, including managed landscapes and 175.26 billion for green industry, including nursery crops and floriculture. Managers and in golf courses, ornamental and managed landscapes, and nursery crops have been encouraged to integrate herbicides with various modes of action as well as nonchemical control options, thereby reducing the evolution of herbicide resistance weeds. However, more and more herbicide resistant weeds in these important commodities have been identified over the last 10 years. Recently, glyphosate resistant *Poa annua*, a common weed in turfgrass and other weed species have been identified. There are only 20 cases reported to the International Survey of Herbicide Resistant Weeds (2018). However, these reported herbicide resistant weeds are not listed under any of these categories, reflecting a need to establish a category for these special important commodities. Incidence and importance of herbicide resistant weeds in agronomic crops have been emphasized in herbicide resistance symposiums and listening sessions for the last decade. There was little emphasis on the importance of herbicide resistance weeds under turfgrass, ornamental and nursery environments. Our goal for the session is to examine the current status of herbicide resistant weeds and to identify potential management programs. Our speakers from academia, government agency and manufacturer will present their research findings, vision, and possible recommendations in combating resistant weeds. It is anticipated that the session will shed light on the role weed scientists should play in developing long term weed management alternatives based on a holistic approach.

PROBLEMS ASSOCIATED WITH CONFIRMING NOVEL RESISTANCE MECHANISM. J. S. McElroy*; Auburn University, Auburn, AL (377)

ABSTRACT

Evaluation of suspected herbicide resistance weed populations normally proceeds from herbicide response evaluations to nucleic acid sequencing in order to identify target site mutations followed by non-target site resistance assays, functional assays, or inheritance studies if necessary to discern the mechanism of resistance. Lack of basic genomic resources can slow this orderly process at the onset. The majority of weed species, especially those that are turfgrass specific weeds, are lacking in information such as genome size, ploidy level, chromosome number, and any genetic sequence on which to base primer development for PCR. Confirming resistance may require an assessment of heritability of the resistant trait to determine if it follows a single locus patter of inheritance. Physical barriers such as flower size, as well as timing of pollen formation and acceptance can confound such studies as little is known about the basic reproductive biology of most weeds found in turfgrass. To adequately determine a target resistance mechanism, all homoeologs of a target site gene within a polyploid species must be sequenced to evaluate all isoforms of a herbicide target protein. Differences in homoeologs can confound amplification in traditional PCR. Transcriptome sequencing can overcome problems associated with traditional PCR amplification by sequencing all expressed mRNA of an organism using de novo assembly and read mapping. Information will be presented regarding the development of the WeedGenomics data repository and further development in conjunction with the International Weed Genome Consortium. The WeedGenomics data repository will continue to be developed to serve as a resource for weed genomics and herbicide resistance mechanism diagnosis.

NOVEL MECHANISMS OF GLYPHOSATE RESISTANCE IN AMARANTHUS SPECIES & ITS IMPLICATION. M. Jugulam*, D. Koo, B. Gill; Kansas State University, Manhattan, KS (378)

ABSTRACT

Evolution of glyphosate resistance in weed species is a major constraint to crop production around the globe. With the introduction and wide acceptance of Roundup Ready crops in many countries, glyphosate has been used extensively for weed control, consequently, many weeds have developed resistance to glyphosate. The target site

of glyphosate is 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS), an important enzyme in shikimate pathway. Several types of mutations or amplification of *EPSPS* gene can bestow weed resistance to this herbicide. Recently, our molecular cytogenetic research indicated the *EPSPS* gene amplification-based resistance to glyphosate in Amaranthus species (e.g. common waterhemp, Palmer amaranth and spiny amaranth). Our data indicated pericentromeric amplification of *EPSPS* copies on one pair of homologous chromosomes as well as on additional chromosomes including various types of ring-chromosome, besides the native chromosome pair in common waterhemp. Development of high-resolution physical maps in Palmer amaranth and spiny amaranth also suggested that the evolution of glyphosate resistance was driven by extra-chromosomal circular DNA (eccDNA) molecules. Each eccDNA carries one or two copies of the target gene *EPSPS*. Our results demonstrated that extrachromosomal based amplification of *EPSPS* gene may be a rapid adaptation of a plant genome to glyphosate resulting in expedited evolution of resistance in new environments. Future understanding of the molecular basis of these novel mechanisms of glyphosate resistance may help use this information for crop improvement which can facilitate the creation of robust herbicide-resistant crops.

A CHANCE TO CHANGE THE ENDING. J. T. Brosnan*; U of TN 252 Ellington Bldg, Knoxville, TN (379)

ABSTRACT

Results of herbicide resistance (HR) management efforts in agricultural production have been mixed considering that reports of weeds evolving resistance to herbicides have steadily increased. HR in fine turfgrass systems such as golf courses, athletic fields, lawns, and sod production is a fairly new problem with only 21 cases reported to the International Survey of Herbicide Resistant Weeds as of 2018; however, the problem has worsened since 2005 with the number of peer-reviewed scientific journal articles on herbicide resistance in turfgrass nearly doubling every five years. Understanding outcomes of recent listening sessions designed to better identify barriers to adoption of HR management practices in agricultural production can be used to develop effective strategies for implementing HR management strategies in turfgrass while the HR problem is still small in scope.

RESISTANT WEED MANAGEMENT IN COOL-SEASON TURFGRASS. S. Askew*; Virginia Tech, Blacksburg, VA (380)

ABSTRACT

The first reported case of herbicide resistance in turfgrass was simazine-resistant annual bluegrass in 1982 followed by pendimethalin-resistant goosegrass in 1988. There are currently 21 cases of resistance to herbicides in 8 weed species reported in scientific literature from turfgrass systems. With over 1500 unique cases of weed resistance reported from other cropping systems, the 21 cases reported from turfgrass might suggest resistance is not problematic in turf systems. To the contrary, unpublished reports from turfgrass weed scientists and lay persons indicate that problems with herbicide-resistant weeds in turfgrass have been growing rapidly in the past decade. For example, of 165 golf superintendents participating in a nation-wide, 2011 survey, 27% reported that herbicide-resistant annual bluegrass was suspected to exist on their golf course. These suspected resistant cases were distributed across 19 U.S. states with 14 cases in the state of California alone. Reports like this survey suggest that the disparity between numbers of crop- and turf-reported cases of herbicide-resistant weeds may be due to differential reporting in the scientific literature as there are equally disparate numbers of scientists conducting research in turfgrass compared to cropping systems. Even so, weed resistance to herbicides is arguably slower to develop in turf systems compared to crop systems. Turfgrass competition represents a powerful "alternate mode of action" for weed mortality that likely slows development of resistance cases. Most cases of herbicide-resistant weeds reported from turf come from unique management conditions, like winter weed control on dormant turf, that more closely mimic seasonal population "screening" indicative of production agriculture.

A MANUFACTURER'S PERSPECTIVE ON HERBICIDE RESISTANT WEEDS IN TURF, ORNAMENTALS AND NURSERY CROPS. J. M. Breuninger*; Corteva Agriscience, Indianapolis, IN (381)

ABSTRACT

Turf and ornamental managers have seen a steady stream of products so herbicide resistance has not been of great historical consequence. This may change though with the rapid development of herbicide resistant weeds and the limited availability of new herbicide tools. New herbicide development has slowed in part due to the expense companies have to bear in discovery, development, and registration of new products with novel modes of action. Manufacturers most often target only the major crops markets for new herbicide products to battle weed resistance. The turf and ornamental market may not always be considered due size or ramifications of the use. To date, selection pressure for herbicide-resistant biotypes in lawn and landscape tends to be less with the occurrence of non-treated areas in close proximity that provide a "refuge" of non-resistant biotypes. Greater risk does exist though in golf, nurseries and areas where there is high selection pressure due to frequency and rate of application on weeds such as *Poa annua, Digitaria* sp., and *Eleusine indica*. Strategies that successfully delay and mitigate the evolution of herbicide-resistant weeds must be in place to preserve and sustain herbicides as viable tools in weed management programs. T&O Manufacturers desire to preserve the use of herbicide products in their portfolios through product stewardship, label directions, and resistance management directions on labels. They also may explore combinations of active ingredients with different modes of action and discover new active ingredients that control resistant weeds. Manufacturers often work in partnership with weed control experts to understand and address weed resistance issues as they occur.

RESISTANT WEED MANAGEMENT IN THE SOUTHERN UNITED STATES. L. Tredway*; Syngenta, Raleigh, NC (382)

ABSTRACT

HERBICIDE-RESISTANCE IN BROADLEAF WEEDS AND SEDGES IN TURFGRASS. P. McCullough*; University of Georgia, Griffin, GA (383)

ABSTRACT

HERBICIDE-RESISTANT WEEDS IN MANAGED LANDSCAPES AND NURSERY CROPS: CURRENT STATUS AND POTENTIAL IMPACTS. J. Derr*[1], J. Neal[2]; [1]Virginia Tech, Virginia Beach, VA, [2]North Carolina State University, Raleigh, NC (384)

ABSTRACT

Herbicide-resistant weeds are present in nursery and landscape plantings but are not as yet having widespread impacts. However, specific crops or cropping situations are vulnerable to greater impacts. Incidences of glyphosate resistant horseweed, ragweed, and pigweeds in field-grown nursery crops are common, and management options for those weeds differ among crop species. In shade tree production, directed applications of glufosinate, paraquat, diquat, or clopyralid may be substituted for glyphosate, depending on the weed species present and tree species. However, evergreen crop species such as Ilex, can be severely injured by these treatments. In such crops, greater reliance on residual herbicide programs with manual rogueing will be required. In NC Fraser fir production, a living ground cover dominated by low growing forbs is maintained for soil stabilization. In such a system the control of glyphosate-resistant horseweed and ragweed has been particularly problematic. Rotation to ALS inhibitor herbicides to control these species raises significant concerns about cross resistance. Of high concern are increased incidences of PPO resistance in agronomic weeds. Nursery crop weed management systems are highly dependent on the PPO inhibitor herbicides oxyfluorfen and flumioxazin. There are concerns in landscape bed maintenance from herbicide-resistant weeds moving from nearby turf areas, horseweed seed blowing in from agronomic crops or noncrop areas, as well as resistance developing due to repeated application of chemicals such as the ACCase inhibitors or the dinitroaniline herbicides. When present, herbicide-resistant weeds increase the cost of production or maintenance by: (1) necessitating more expensive herbicides, (2) increased number of herbicide applications (3) increasing labor costs for manual removal, and (4) increased management personal time invested in weed monitoring and planning.

RESISTANT WEEDS IN MANAGED LANDSCAPES AND NURSERY CROPS. J. Neal*; North Carolina State University, Raleigh, NC (385)

ABSTRACT

CRITICAL NEXT STEPS IN COMBATING HERBICIDE RESISTANCE: WHAT WE HEARD, THINK AND PLAN ON DOING AFTER THE RESISTANCE LISTENING SESSIONS. M. Barrett*[1], J. Schroeder[2], D. R. Shaw[3], A. Asmus[4], D. E. Ervin[5], R. Jussaume[6], H. D. Coble[7]; [1]University of Kentucky, Lexington, KY, [2]USDA Office of Pest Management Policy, Arlington, VA, [3]Mississippi State University, Mississippi State, MS, [4], Rake, IA, [5]Portland State University, Portland, OR, [6]Michigan State University, East Lansing, MI, [7]USDA, Cary, NC (386)

ABSTRACT

Since its inception in 2010, the Herbicide Resistance Education Committee has been very active in developing materials and outreach activities to address this issue. These materials include publications on resistance best management practices, on-line training modules, fact sheets, infographics, and a soon to be launched webpage that will serve as a gateway to other management resources for herbicide resistance. Outreach activities included two national summits on herbicide resistance held in Washington, DC. The first in 2012 laid out the situation with herbicide resistance for policy makers while the second in 2014 focused on the roles and actions each stakeholder group needed to take to combat resistance development. Soon after the committee began its work, it became apparent to the members that the problem of herbicide resistance, and any solutions, was really as much a social issue, rather than one of science, education or weed science. Early on the committee recruited several social scientists to join and their thoughts and involvement were instrumental in the activities described above. It remains important that weed scientists form collaborations with other disciplines and with experts from industry, including farmers and production advisers, and government, i.e., transdisciplinary approaches, to lessen some of the social and economic barriers to herbicide resistance management (HRM) and, overall, more integrated approaches to weed management.

Despite all the activity of the committee, the members are still very concerned with the continued reports of new resistance cases. While awareness of herbicide resistance issues has certainly increased, the committee feels that there is still an unacceptable increase in resistance. Because of this, the committee decided to take a different approach.

Seven half-day regional listening sessions were held around the country between December 2016 and April 2017 with groups of diverse stakeholders on the issues and potential solutions for HRM. These listening sessions were different from typical extension-type meetings as the objective was for the participants to articulate what their challenges and recommendations for addressing HRM were rather than hear solutions from "experts". A complete description of the approach to holding these sessions and what we heard is in Weed Technol. 32:489 and 32:475. Overall, the participant evaluations from the sessions were positive, with participants expressing appreciation that their opinions and ideas on HRM were valued. Six themes summarize the messages shared by listening-session participants: we need new herbicides; there is no need for more regulation; there is a need for more education, especially for others who were not present; diversity is hard; the agricultural economy makes it difficult to make changes; and we are aware of herbicide resistance but are managing it.

A subgroup of the organizers took these messages and considered how to address some of them. These opinions were published as a "My View" article in Weed Science (66:559). The first thought is that a comprehensive and vigorous educational campaign must be mounted to help stakeholders understand that new herbicide chemistries are a long way off at best. The message on this must be consistent among academics, industry, and commodity groups, among others, to be successful. Second, we need to see if WSSA, working with industry and policymakers, can find ways to remove barriers to new herbicide discovery and to use thoughtful regulation, or even the threat of regulation, to promote best management practices. An emphasis on the positives, and success stories, of effective proactive HRM and the creation of community-based cooperative efforts on HRM in messaging could encourage others to try more of this. We need an initiative to ***identify*** communities that, at the least, have made an effort to develop a group oriented HRM program(s) and, at the same time, ***identify*** comparable communities that have not. We also need to develop research objectives to address data gaps for HRM and computer apps to rate the effectiveness of herbicide mixtures and sequential applications for HRM with particular weed populations. Disincentives in public and private sector policies to incorporating effective HRM practices, such as tillage, need to be reduced or eliminated but we also need research to minimize soil damage from tillage and how to incorporate it and other HRM practices into farming systems. One overarching theme is the need for all parties involved in HRM to work together more and to deliver a consistent message. An extension of this is the need to create community-based cooperative efforts on HRM and limit the spread of resistance. The committee is exploring avenues to catalyze formation of these communities. The authors also challenged several WSSA committees to consider working on these issues.

INTRODUCTION TO SYMPOSIUM AND AREA-WIDE PROJECTS. L. M. Lazaro*; Louisiana State University AgCenter, Baton Rouge, LA (387)

ABSTRACT

Herbicide-resistant weeds are an issue in every cropping system today. For many years, the availability of convenient, effective, affordable herbicides and tolerant crop genetics has allowed producers to streamline weed control. However, the rapid rise in multiple herbicide-resistant weeds in the US has rendered that these populations can no longer be managed with simple herbicide programs. Increasingly, problematic weeds demand a diversified approach for effective management. The objectives of this symposium are to highlight a national team of researchers, extension specialists, and economists spanning three distinct grain producing regions of the US (North Central,

South Central, and Mid-Atlantic); and portray the ongoing efforts to quantify, demonstrate, and increase the adoption of integrated weed management (IWM) systems to help growers regain control of multiple herbicide-resistant weeds. This symposium will specifically highlight current research and outreach on multi-tactic management of herbicide-resistant weeds and identify thrust areas for further improvement of IWM adoption.

HAVE WE GOTTEN LOST IN THE WEEDS? WHERE WE'VE BEEN AND WHERE WE'RE HEADED WITH WEED MANAGEMENT IN U.S. AGRICULTURE. K. Bradley*; University of Missouri, Columbia, MO (388)

ABSTRACT

Herbicide-resistant weed populations have evolved rapidly in response to the selection pressures imposed upon them in current agricultural production systems. The number of acres impacted by glyphosate-resistant (GR) weeds has increased dramatically in recent years due to the rapid adoption of GR crops and extensive use of glyphosate. Many of these GR weed species have now evolved multiple resistance (MR) to herbicides that act at alternative sites of action. One of the GR and MR weed species that is currently infesting the majority of corn and soybean acres in the Midwest is waterhemp (*Amaranthus rudis* Sauer). In this presentation, I will present a history of our educational efforts related to the management and mitigation of waterhemp since our initial discovery of the first GR waterhemp biotype in 2004. Successes and failures will be highlighted, particularly in the context of our efforts to change farmer's attitudes towards weed management. Given the prevalence of GR and MR weed species like waterhemp in current production systems, some future directions for weed management will be presented.

THE IMPORTANCE OF HARVEST WEED SEED CONTROL IN INTEGRATED WEED MANAGEMENT DECISIONS. M. J. Walsh*; University of Sydney, Narrabri, Australia (389)

ABSTRACT

The loss of herbicides due to resistance threatens the future of the highly productive conservation cropping systems has been the motivation for growers to develop and adopt alternate systems. Subsequently, one of these alternative approaches, harvest weed seed control (HWSC), was developed to target weed seed passing through the harvester during grain harvest. Since they were first introduced almost 30 years ago, there has been an almost continual evolution HWSC systems. High efficacy combined with more user-friendly HWSC systems has driven substantial adoption of this approach in recent years. In 2014 a survey of Australian growers determined that 42% were currently using HWSC with this number expected ton increase to 82% by 2019. As the adoption of HWSC systems continues to grow there will be an increasing demand for more refined systems that are easier to use and have minimal impact on harvest efficiency. Similarly, with HWSC now being considered in a range of global cropping systems, there is an increasing need for the adaptation of HWSC systems for these situations. The use of these systems has allowed growers to reduce and maintain weed populations at very low levels (<1.0 plant m^{-2}). These low weed densities create the opportunity for substantial gains in the efficiency of weed control through the applicaiton of site-specific treatments.

CURRENT STATUS AND FURTURE OF HARVEST WEED SEED CONTROL IN THE US. M. V. Bagavathiannan*[1], J. K. Norsworthy[2], L. M. Lazaro[3], S. Mirsky[4], M. J. Walsh[5]; [1]Texas A&M University, College Station, TX, [2]University of Arkansas, Fayetteville, AR, [3]Louisiana State University AgCenter, Baton Rouge, LA, [4]USDA-ARS, Beltsville, MD, [5]University of Sydney, Narrabri, Australia (390)

ABSTRACT

WEED SEED RAIN PHENOLOGY: AN AREAWIDE APPROACH. L. M. Lazaro*[1], J. Evans[2], J. K. Norsworthy[3], S. B. Mirsky[4], A. S. Davis[5], K. Bradley[6], L. E. Steckel[7], M. V. Bagavathiannan[8], J. A. Bond[9], J. Lindquist[10], N. R. Jordan[11], M. L. Flessner[12], M. J. VanGessel[13], W. Everman[14], W. S. Curran[15], N. E. Korres[3]; [1]Louisiana State University AgCenter, Baton Rouge, LA, [2]Farmscape Analytics, Concord, NH, [3]University of Arkansas, Fayetteville, AR, [4]USDA-ARS, Beltsville, MD, [5]N-319 Turner Hall, Urbana, IL, [6]University of Missouri, Columbia, MO, [7]University of Tennessee, Jackson, TN, [8]Texas A&M University, College Station, TX, [9]Delta Research and Extension Center, Stoneville, MS, [10]University of Nebraska, Lincoln, NE, [11]University of Minnesota, St. Paul, MN, [12]Virginia Tech, Blacksburg, VA, [13]University of Delaware, Georgetown, DE, [14]North Carolina State University, Raleigh, NC, [15]Penn State University, Bozeman, MT (391)

ABSTRACT

An USDA Agricultural Research Service (ARS) area-wide funded integrated weed management (IWM) team of researchers and extension specialists was formed to address the issue of how to incorporate IWM on multiple herbicide-resistant weeds, which includes traditional research, social and economic analyses, and extension components. One research topic was to address the phenology of weed seed shatter across various agriculturally important regions. Typically, when harvesting occurs the weed seed has already either shattered or has been pulled through the combine. Thus, the weed seeds are being redistributed on the soil surface causing further spread as well as increasing the soil seedbank. However, there is little research on the quantity of seed that is retained on different weed species at harvest time, especially over large geographic ranges. Thus, the objective of this study was to determine the amount of weed seed production that was shattered or retained on the plant at and after soybean (*Glycine max* L. Merr) physiological maturity and to determine which weed species were viable for harvest weed seed control (HWSC). A two-year trial was conducted across fourteen states, where twenty-five different species were observed (sixteen broadleaf and nine grass species). At the onset of inflorescence, four flats were placed underneath the targeted weeds and seed shatter was assessed weekly until one month after soybean maturity. At that time, the targeted weeds were collected to determine biomass and final seed retention. Fifteen total species were used in the analyses. Overall, the grass species began to shatter their seed prior to soybean maturity, whereas the broadleaf species began seed shatter at or after soybean maturity. At soybean maturity, the targeted broadleaf species in general had retained 90% or greater of their seed. The four *Amaranthus* species retained 99% of their seeds at harvest and shattering 0.1% seeds daily between soybean maturity and harvest. Our research determines that soybean maturity and harvest dates are critical in weed seed shatter. Weeds must not be allowed to produce seed and must be controlled by soybean maturity to reduce the amount of weed seed that can enter the soil seedbank. In general, the broadleaf species were all viable candidates for HWSC, whereas the grasses were not. In addition, US regions did not have a great effect on seed shatter between similar species. Environmental factors should be examined to determine their influence on weed seed shatter.

ROLE OF COVER CROPS AND TILLAGE IN WEED MANAGEMENT. W. S. Curran*[1], J. M. Wallace[2]; [1]Penn State University, Bozeman, MT, [2]Penn State University, University Park, PA (392)

ABSTRACT

Integrated weed management efforts should include cultural and mechanical tactics to help create a diverse program that is robust, resilient and prevents the evolution of resistant or tolerant weeds. In the absence of effective herbicides, nonchemical tactics are even more critical for successful long-term management of weeds. Our past research has focused in two primary areas. 1.) how to optimize winter cover crop growth and biomass to maximize weed suppression and 2.) evaluate the weed control potential of shallow tillage tools in no-till corn and soybean. Our cover crop research has examined cover crop species, planting and termination dates, seeding rates, and the impact of supplemental nitrogen. In a nutshell, a competitive high biomass cover crop in the spring is paramount to the success of this system. Winter annual weeds are more easily suppressed in these systems, while summer annual weed control is more variable and truly require a more intensive cover crop management approach. In a recent no-till soybean study, cover crop treatments reduced horseweed (*Conyza canadensis* (L.) Cronq.) density 52 to 86% at the time of a pre-plant, burndown application in comparison to the fallow control. Cereal rye (*Secale cereal* L.) alone or in combination with forage radish (*Raphanus sativus* L.) provided the most consistent horseweed suppression compared to oats (*Avena sativa* L.) and hairy vetch (*Vicia villosa* Roth) monocultures or mixtures. In other research, mechanical control treatments examined a vertical coulter, a rotary harrow, a high-residue rotary hoe, and a high-residue row cultivator. The most successful mechanical weed control tool in our research has been the inter-row cultivator designed to operate in high residue environments. A pre-plant vertical coulter/rotary harrow (e.g. Great Plains Turbo-till) tended to control small annual weeds as well as a standard burn down herbicide program, but effective control was short lived and variable for some weed species. The high residue rotary hoe provided inconsistent early-season weed control. In one study, the high residue inter-row cultivator reduced weed biomass by 53% without any supplemental residual herbicides and 88% with a banded residual herbicide compared to the weedy check treatment. In other research, two cultivator passes reduced weed biomass to 500 kg ha^{-1} or less and were needed to optimize weed control and prevent yield loss. Finally, we advocate for advancement in our understanding of complementarity between cover crop- shallow tillage mechanical weed control tools, and herbicide-based management tactics in no-till systems to facilitate development of pro-active, herbicide resistant management strategies.

A NATIONAL ASSESSMENT OF COVER CROPS IN AN IWM PROGRAM. S. Mirsky*[1], J. K. Norsworthy[2], A. S. Davis[3], M. V. Bagavathiannan[4], J. A. Bond[5], K. Bradley[6], W. S. Curran[7], J. Evans[8], W. Everman[9], M. L. Flessner[10], G. Frisvold[11], N. R. Jordan[12], L. M. Lazaro[13], J. Lindquist[14], L. S. Shergill[6], L. E. Steckel[15], M. J. VanGessel[16]; [1]USDA-ARS, Beltsville, MD, [2]University of Arkansas, Fayetteville, AR, [3]N-319 Turner Hall, Urbana, IL, [4]Texas A&M University, College Station, TX, [5]Delta Research and Extension Center, Stoneville, MS, [6]University of Missouri, Columbia, MO, [7]Penn State University, Bozeman, MT, [8]Farmscape Analytics, Concord, NH, [9]North Carolina State University, Raleigh, NC, [10]Virginia Tech, Blacksburg, VA, [11]University of Arizona, Tucson, AZ, [12]University of Minnesota, St. Paul, MN, [13]Louisiana State University AgCenter, Baton Rouge, LA, [14]University of Nebraska, Lincoln, NE, [15]University of Tennessee, Jackson, TN, [16]University of Delaware, Georgetown, DE (393)

ABSTRACT

CROP ROTATION AND CROPPING SYSTEM DESIGN FOR EFFECTIVE WEED MANAGEMENT. M. Liebman*, V. Nichols, D. Weisberger; Iowa State University, Ames, IA (394)

ABSTRACT

Heavy reliance on herbicides for weed suppression has led to two critical challenges for weed managers: a growing number of herbicide-resistant weeds and off-site movement of herbicides with toxic effects on non-target organisms. Spreading the burden of crop protection across multiple weed management tactics is often suggested as a means of minimizing herbicide use, reducing selection for herbicide resistance, and better protecting environmental quality, while lessening risks of control failure. The use of diversified crop rotation systems may fit well with the implementation of multi-tactic weed management strategies.

We conducted a meta-analysis to quantitatively assess the effects on weeds of diversifying cropping systems by increasing the length and species richness (S) of rotation sequences. While excluding experiments focusing on cover crops, we used 298 paired observations from 54 studies to compare monocultures (S=1) with more diverse crop sequences (S≥2), and simple rotations (S=2) with more diverse rotations (S≥3). Relative to simple cropping systems, mean weed density (plants/m^2) in more diverse rotations was reduced 49% ($p<0.001$). The suppressive effect of diversified rotations on weed density was evident whether or not herbicides were used and was more pronounced in zero-tillage systems than tilled systems. In contrast to the pattern for weed density, the effect of diversifying crop rotations on weed biomass (g/m^2) was weaker (21% lower than in simpler systems) and not significant ($p=0.22$). These results indicate that special attention should be directed toward identifying practices within rotation sequences that limit the growth of established weeds.

Modeling analyses also provide an important means of assessing the weed-related effects of contrasting crop rotation systems. Using published demographic parameters for giant ragweed (Ambrosia trifida L.), a problematic, herbicide-resistant species in the central U.S., we built a difference equation model to examine how diversifying a corn-soybean rotation would affect the weed's population dynamics. We assumed that herbicides applied to corn and soybean might be less than 100% effective in suppressing giant ragweed, but that unsprayed solid-seeded crops harvested in mid-summer, such as winter cereals and forages, could prevent reproduction by the weed. We found that to preclude an increase in giant ragweed population density, the minimum control efficacy needed from herbicides applied to corn and soybean was 99.2% in a 2-year rotation of those crops, but was 92.6% in a 5-year winter cereal-alfalfa-alfalfa-corn-soybean rotation. Thus, the diversified rotation would be better buffered against less-than-perfect weed control in corn and soybean, while allowing for a 60% overall reduction in herbicide use.

We conclude that while not a panacea, diversification of crop rotations can serve as a powerful organizing principle under which technological innovations and ecological insights can be joined to better manage weeds and contribute to more sustainable farming systems.

REGIONAL DISCUSSION BREAKOUT: WHAT IS ADOPTABLE, PRACTICAL, AND ECONOMICAL IN EACH REGION. L. M. Lazaro*; Louisiana State University AgCenter, Baton Rouge, LA (395)

ABSTRACT

Regional Discussion Breakout: What is Adoptable, Practical, and Economical in each region

ADDRESSING LONGTERM INTEGRATED WEED MANAGEMENT DECISIONS THROUGH MODELING. J. A. Evans*[1], A. S. Davis[2], G. Frisvold[3], S. B. Mirsky[4]; [1]Farmscape Analytics, Concord, NH, [2]N-319 Turner Hall, Urbana, IL, [3]University of Arizona, Tucson, AZ, [4]USDA-ARS, Beltsville, MD (396)

ABSTRACT

What is the investment value of a dollar spent on weed management today? Farmers facing uncertainty about the future efficacy of conventional herbicides should be turning to a more diverse suite of integrated weed management (IWM) tactics, but many are reluctant to do so because they view weed management as a cost, rather than an investment. IWM methods can range from crop diversification to modified tillage and hand weeding. For many, this represents a major shift in their farm management practices, and only substitutes one type of uncertainty for another. Our aim was to develop a framework to evaluate a number of IWM tactics and address questions about their economic viability. Ultimately, most farmers are concerned with predictability, and want to forecast the future returns on capital invested in their operations today. In this study, we examined two IWM tactics and asked how coordinating their adoption at large, area-wide scales impacted their combined efficacy and potential financial success. We began with a previously published cellular automata spatial simulation model of herbicide resistance (HR) evolution and spread in a weed demographically similar to *Amaranthus tuberculatus* (common waterhemp) that could evolve resistance to an herbicide comparable to glyphosate, but with simple Mendelian inheritance. The landscapes were built of individual farm fields following a corn-soy rotation and grouped into hierarchically organized, contiguous weed management units: farms, coops, and CWMAs (cooperative weed management areas) which ranged from ~400-40000 ha in size. Using this, we compared the interactions of two herbicide tank mixtures (glyphosate plus either one or four other herbicide mechanisms of action, the "discount" and "premium" programs, respectively) with harvest time weed seed control implemented with a combine-mounted Harrington Seed Destructor (HSD), a cage mill that pulverizes 99.99% of the weed seeds it ingests. In sequential runs, herbicide and HSD treatments were assigned to management units coordinated at the farm, coop, or CWMA scales. Within a given management unit all fields adhered to the same management schedule (e.g. all corn fields within a coop used the same herbicides during a given year in the coop-scale management simulation, etc.). Model results indicate that both weed management system and spatial scale have important consequences for management efficacy and economics: 1) Overall, the premium herbicide treatment lowered weed population densities and reduced yield losses more effectively than the discount treatment. 2) Using the HSD with either herbicide treatment further reduced weed populations and yield losses, but 3) only at scales larger than individual farms. 4) At scales larger than farms, HR rates were enriched by use of the HSD, albeit within very small weed populations. 5) Positive economic returns on investments in HSD technology were dependent on operating each HSD over large areas and in combination with the premium herbicide treatment. If the cost of HSD technology decreases, it may eventually become economically viable to implement at smaller scales. Because the HR trait we modeled had no metabolic cost, the frequency of HR increased over time in all treatment combinations.

GROW (GETTING RID OF WEEDS): A NATIONAL EXTENSION EFFORT DRIVING ADOPTION OF INTEGRATED WEED MANAGEMENT. M. L. Flessner*[1], M. J. VanGessel[2], M. V. Bagavathiannan[3], L. M. Lazaro[4], K. B. Pittman[1], C. G. Rubione[2], S. B. Mirsky[5]; [1]Virginia Tech, Blacksburg, VA, [2]University of Delaware, Georgetown, DE, [3]Texas A&M University, College Station, TX, [4]Louisiana State University AgCenter, Baton Rouge, LA, [5]USDA-ARS, Beltsville, MD (397)

ABSTRACT

Michael L Flessner, Mark J VanGessel, Muthukumar V Bagavathiannan, Lauren M Lazaro, Kara B Pittman, Claudio G Rubione, Steven B Mirsky, Annie Klodd, Mandy Bish, William Curran, and Adam Davis

GROW is an USDA Agricultural Research Service (ARS) funded area-wide integrated weed management (IWM) initiative involving a national team of researchers and extension specialists. The project "An integrated pest management approach to addressing the multiple herbicide-resistant weed epidemic" includes traditional research, socio-economic analyses, and outreach and technology transfer (i.e. extension) components.

Extension efforts are multifaceted and aimed at increasing knowledge and adoption of IWM practices. To prioritize subsequent efforts, a national IWM survey was conducted to gauge current understanding and adoption of IWM across the US. The survey data and literature indicate that many farmers are routinely using some IWM practices, many farmers are unclear about multiple, effective herbicides sites of action, and many farmers are unsure about herbicide use combined with alternative management tactics. Literature further indicates that best practices to accelerate adoption should (1) focus on a tactic that is easy to adopt, (2) consist of compelling scientific data, and (3) be delivered to a targeted audience to leverage both farmer preference for peer-to-peer learning and their media use habits.

Additional extension efforts include online content in the form of a website (integratedweedmanagement.org) and the social media platforms: Twitter (@GetRidofWeeds), Facebook (facebook.com/GetRidofWeeds/), and YouTube (GROW IWM channel). The website provides a centralized source of reliable IWM information that includes existing/linked content as well as original content. The website also hosts a question/answer forum on IWM, allows users to subscribe to articles and updates, and catalog herbicide-resistant weeds in each state. Social media platforms have a three-part objective: to drive users to the website, encourage peer-to-peer interactions, and find and connect to early adopters.

Lastly, we are developing two decision-support tools. Effective site of action (ESOA) will be an app and web-based tool that reports the number of ESOA, risk categories for herbicide resistance, and herbicide product alternatives to increase ESOA, after the user inputs their crop, dominant weed(s), and herbicide(s) or herbicide program. Palmer Amaranth Management (PAM; https://agribusiness.uark.edu/decision-support-software.php#PAM) is a decision-support tool to evaluate the impact of various management practices on Palmer amaranth (*Amaranthus palmeri*) seedbank dynamics and economic returns. PAM will be expanded to include research and educational modules for crop rotation, tillage, and other practices; increase the geographic region of inference; and link to other open-source decision support platforms.

SOCIOECONOMICS. G. Frisvold*; University of Arizona, Tucson, AZ (398)

ABSTRACT

This presentation explains how well-known socioeconomic phenomena create barriers to herbicide-resistance management and highlight important c and costly standards and incentives, which can be effective in the near-term but are unsustainable, to more-targeted and less-costly approach

WHERE IS INTEGRATED WEED MANAGEMENT HEADED? J. K. Norsworthy*; University of Arkansas, Fayetteville, AR (399)

ABSTRACT

Herbicide resistance continues to increase at an alarming rate, and metabolic resistance to herbicides is beginning to challenge the thought that herbicides alone will remain an effective option into the near future. For this reason, there is a strong need to revisit the biology of some of the most resistant prone weeds, identifying weaknesses that can be exploited to minimize emergence or reduce returns to the soil seedbank. Practical approaches involving cover crops, tillage, and other nonchemical approaches must be tailored to crops and regions, considering topography and length of growing season. Additionally, practices must be integrated into cropping systems in a manner that the system as whole remains profitable. Feasibility or ease of implementation must be considered because farm size and availability of farm labor is decreasing. Two of the newest innovations that have high potential for adoption across large acreage agriculture are the integrated Harrington Seed Destructor and use of weed recognition sprayers that more efficiently utilize postemergence herbicides and reduce environmental loading. Integration of these two tools with other diverse weed management practices that maintain low or declining soil seedbanks are critical to developing a sustainable weed management program.

ANTIMALARIAL HERBICIDES AND HERBICIDAL ANTIMALARIALS: EXPLOITING THE PLANT-*PLASMODIUM* CONNECTION. J. S. Mylne*; The University of Western Australia, Perth, Australia (400)

ABSTRACT

Plants and apicomplexan parasites are more closely related than many might expect. Both evolved from a red algal ancestor and both still possess plastids. Plants have chloroplasts whereas apicomplexans like the malarial parasite *Plasmodium falciparum* have an apicoplast. This diminished 'relic' plastid and is no longer photosynthetic, but remains essential for its production of isoprenoid precursors. Proof the apicoplast was of plant origin was provided, in part, by killing *P. falciparum* with herbicides. We recently turned this idea on its head asking whether drugs designed to treat malaria might be herbicidal and found many indeed were. This has led us to apply the rapid advances in malaria research over the last decade to the field of herbicide discovery. The success of glyphosate and spiralling cost of bringing new compounds to market stalled discovery programs by agrochemical companies and no new herbicide mode of action has reach the market in several decades. Herbicide resistance also has growers concerned. Using antimalarial drug libraries and knowledge of malarial drug action, we are attempting to put as many new modes of action 'on the table' as we can, each accompanied by an herbicidal molecule to probe each target. A by-product of this applied work has already been knowledge about what, in many cases, are under-studied plant proteins.

INVESTIGATING THE ROLE OF ALLELIC CONTRIBUTION TO GLYPHOSATE RESISTANCE IN POLYPLOID WEED SPECIES. S. Morran*[1], C. A. Brunharo[2], M. Jasieniuk[1], B. Hanson[3]; [1]University of California, Davis, Davis, CA, [2]Oregon State University, Corvallis, OR, [3]University of California, Davis, Winters, CA (401)

ABSTRACT

Polyploidy is common in plant species and general occurs as a result of genome doubling following hybridization, or within one species. Many problematic agricultural weed species are polyploid or had a polyploidy event in their lineage. Polyploid species are thought to have a competitive advantage in a broader range of environments due to increased heterozygosity, plasticity and phenotypic variability compared to their diploid progenitors. One consequence of polyploidy is an altered expression or differentiation of genes when compared to progenitors, where many ancient polyploids show a dominance of one sub-genome over others. Interestingly, an increasing number of polyploid species are being found to differentially alter gene expression between parental gene copies in response to stress, possibly ameliorating the negative fitness cost associated with constitutive expression of some adaptive traits. These factors can affect the interpretation of mechanisms of resistance to herbicides, both target-site and multigenic, in polyploid weeds. Here we investigate how the contribution of resistant and susceptible alleles to total expression in two polyploid species; *Poa annua* (tetraploid, 2n=4x=28) and *Echinochloa colona* (hexaploid, 2n=6x=54) may relate to their resistance to glyphosate. Multiple populations were analyzed with resistant plants containing a target site mutation at PRO106 and susceptible containing the wild type codon of the 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) gene. These studies showed a sub-genome dominance of the diploid progenitor *P.supina* EPSPS allele in the resistant *P.annua* line that was not observed in the susceptible line. *E. colona* lines showed variable expression of mutant EPSPS alleles between populations. Little is known about the relative genomic contributions of resistance loci in weedy polyploid plants and how this may relate to fitness cost and/or adaptation to changing environments. Understanding this process will contribute in forwarding our knowledge of the complexities of resistance in polyploid weed species and our ability to manage them in different agricultural systems.

COMPARATIVE ANALYSIS OF GLYPHOSATE RESISTANT AND SENSITIVE GENOMES INDICATES GENOME REARRANGEMENT AS A MECHANISM OF RAPID ADAPTION. E. L. Patterson*[1], W. Molin[2], D. G. Peterson[3], C. A. Saski[1]; [1]Clemson University, Clemson, SC, [2]USDA-ARS, Stoneville, MS, [3]Mississippi State University, Mississippi State, MS (402)

ABSTRACT

PHOTOOXIDATIVE STRESS CONDITIONS ELICIT CONTRASTING RESPONSES IN PARAQUAT RESISTANT AND SUSCEPTIBLE ITALIAN RYEGRASS BIOTYPES. C. A. Brunharo*[1], B. Hanson[2]; [1]Oregon State University, Corvallis, OR, [2]University of California, Davis, Winters, CA (403)

ABSTRACT

A paraquat-resistant population of Italian ryegrass (PRHC) identified in a prune orchard in California appears to exhibit vacuolar sequestration of the herbicide. The objective of this research was to characterize the response of PRHC to paraquat under different temperatures compared to a known paraquat-susceptible biotype (S). Dose-response experiments were conducted in growth chambers at 30/24 C (day/night) and at 16/10 C with paraquat concentrations that varied from 0 (nontreated) to 7040 g ai ha^{-1}. To test the effects of photooxidative stress conditions, PRHC and S were exposed to constant light at 1000 mmol m^{-2} s^{-1} and constant temperature at 8 C for 96 hours, and the chlorophyll fluorescence data were collected over time. The activity of reactive oxygen species scavenging enzymes of plants incubated at 30/24 C and 16/10 C was also quantified. The lower temperature growing condition increased the GR_{50} of PRHC by 21 times, whereas a reduced response was observed in S. Chlorophyll fluorescence in S was reduced to 20% by 96 HAT, whereas these values maintained at >75% in PRHC, suggesting that PRHC is more adapted to photooxidative conditions. A higher activity of superoxide dismutase was observed in PRHC compared to S, whereas the enzyme activity of ascorbate peroxidase, catalase, and glutathione reductase was similar between PRHC and S. Our results suggest that vacuolar sequestration of paraquat may not be the sole resistance mechanism in PRHC.

ABIOTIC STRESSORS AND HERBICIDE DIFFERENTIALLY REGULATE THE GLOBAL METABOLOME OF *AMARANTHUS PALMERI* BIOTYPES THAT EXHIBIT CONTRASTING GLYPHOSATE SUSCEPTIBILITIES. N. Tharayil*[1], E. M. Leonard[2], V. K. Nandula[3], S. O. Duke[4]; [1]Clemson University, Clemson, SC, [2]Clemson University, CLEMSON, SC, [3]USDA-ARS, Cleveland, MS, [4]USDA-ARS-NPURU, Oxford, MS (404)

ABSTRACT

Palmer amaranth (*Amaranthus palmeri*) biotypes that have evolved resistance to the most widely used herbicide glyphosate is a serious threat to the productivity and profitability of the row-rop production systems in Southern US. The amplification of the gene that codes for the 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase, the target enzyme of glyphosate, is the primary driver of glyphosate resistance in *A. palmeri*. EPSPS is the penultimate enzyme of the shikimate pathway, the key pathway that links the primary and secondary metabolism in plants, to which more than 30% of photosynthetic carbon is committed. Shikimate pathway, through the production of phenylalanine, drives the phenlypropanoid pathway, which results in the biosynthesis of polyphenols. Phenolics including flavonoids are often upregulated and positively correlated with stress adaptation in Plantae. Since both EPSPS gene amplification and environmental stress could potentially influence the C flow through phenylpropanoid pathway, we hypothesized that both glyphosate and drought would elicit similar cellular-level responses in *A.palmeri* with EPSPS gene duplication. We tested this hypothesis by contrasting the dynamics of both primary and secondary metabolites in two glyphosate susceptible (S) and three glyphosate resistant (R) biotypes of *A. palmeri* under drought and herbicide stress.

Global profiling of primary metabolites using gas-chromatography mass-spectrometry and secondary metabolites using liquid-chromatography coupled to ultra-high resolution accurate mass (UHRAM) mass spectrometry identified more than 40,000 mass features, which were curated to 72 primary metabolites and 1,893 secondary (polar) metabolites, and were further processed with molecular ion network and path analysis. Sixty eight of the primary metabolites and 1,524 secondary metabolites showed significant treatment response across the five biotypes. The cellular physiology of R-biotypes were innately different from that of the S-biotypes in the absence of stressors, where the former was abundant in TCA metabolites and carbohydrates, whereas the later had a higher relative abundance of intermediaries of shikimate pathway upstream of shikimic acid. From more than 200 phenylpropanoids that were identified, the R-biotypes had a proportionately greater abundance of flavonoids, especially glycosylated flavonols. With respect to stressors, compared to their respective water treated controls, both stressors resulted in down regulation of ~90 compounds across the five biotypes, whereas glyphosate treatment resulted in upregulation of twice as many metabolite (~750) than the drought treatments across the five biotypes. Though similar in numbers, the molecular identity of compounds upregulated were dissimilar between the S- and R-biotypes across the stress treatments, with S-biotypes upregulating monophenolics, whereas the R-biotypes preferentially upregulating flavonoids with greater anti-oxidant capacity. Our results provide preliminary support to the notion that due to the potentially higher inducibility of pheylpropanoid pathway conferred by EPSPS gene duplication, some of the R-biotypes of *A. palmeri* could exhibit a greater tolerance to environmental stressors.

EXPRESSION VARIATION IN PHENOXY RESISTANT AND SUSCEPTIBLE BUCKHORN PLANTAIN (*PLANTAGO LANCEOLATA*) FOLLOWING 2,4-D EXPOSURE. J. S. McElroy*[1], A. J. Patton[2], P. McCullough[3], Q. D. Law[4]; [1]Auburn University, Auburn, AL, [2]Purdue University, W Lafayette, IN, [3]University of Georgia, Griffin, GA, [4]Purdue University, West Lafayette, IN (405)

ABSTRACT

RNA-Seq analysis was conducted to evaluate differential expression in 2,4-D resistant and susceptible buckhorn plantain (*Plantago lanceolata*) 24 hours after 2,4-D treatment. In general, the susceptible biotype enriched numerous GO terms associated with parasitism, pathogen infection, and miscellaneous external biotic stress whereas such GO terms were not enriched in the resistant biotype. Two auxin associated GO categories were also enriched in susceptible, auxin efflux transmembrane transporter activity (GO: 0010329) and auxin transmembrane transporter activity (GO: 0080161), whereas no auxin-associated GO categories were enriched in resistant. Upregulated gene-level transcripts associated with plant defense response and parasitism were also observed in the susceptible but not in the resistant biotype. With respect to gene families associated with enhanced metabolic-based non-target site resistance, more gene level transcripts of cytochrome-P450s, glutathione S-transferases, and ABC transporters were upregulated in the susceptible biotype than the resistant biotype following 2,4-D treatment. Of the Aux/IAA repressors and TIR1/AFBs, no nonsynonymous mutations were observed in regions of auxin interaction. While it seems that 2,4-D resistant buckhorn plantain is not perceiving exogenously applied 2,4-D based on differential expression, the mechanism preventing perception remains unknown. Further research evaluating non-treated resistant and susceptible biotypes is currently being conducted.

MECHANISMS OF GLYPHOSATE RESISTANCE IN PALMER AMARANTH: INSIGHTS FROM TRANSCRIPTOME AND EPIGENETIC PROFILING. W. Molin*[1], C. A. Saski[2]; [1]USDA-ARS, Stoneville, MS, [2]Clemson University, Clemson, SC (406)

ABSTRACT

Resistance to glyphosate in *Amaranthus palmeri* is the result of amplification of the 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) gene and increased expression of the target site of glyphosate, EPSP synthase. Recent reports have shown that resistance to glyphosate is accompanied by dynamic structural changes in the genome that results in the formation of an extra-nuclear circular DNA (eccDNA) entity, in which each eccDNA cassette harbors a copy of the EPSPS gene. It also has been shown that the genomic landscape adjacent to the EPSPS gene in glyphosate resistant *Amaranthus palmeri* is repetitive, and endowed with transposable elements. To fully understand the genetic architecture of resistance to glyphosate in the context of gene expression, we compared and contrasted the transcriptional profiles of two contrasting biotypes (glyphosate sensitive (S) and resistant(R)) inder treatment with glyphosate, surfactant, surfactant + glyphosate, and water only controls at 4 and 20 hours, respectively. After *de novo* transcriptome assembly and stringent filtering, we arrived at a total of 60,464 transcripts with putative functional domains. By using differential gene expression profiling and post-hoc multivariate discrimination analyses, we identified approximately 1,500 genes that seemingly function in metabolizing, transporting and detoxifying the resistant biotype of glyphosate. Furthermore, we used whole genome bisulfite conversion to assess and compare CHG, CHH, and CpG methylation status in glyphosate sensitive and resistant biotypes. An integrated model of methylation and gene expression profiles that correlates with glyphosate resistance will be presented.

IS RESISTANCE TO PPO INHIBITORS IN PALMER AND WATERHEMP EXPLAINED SOLELY BY TARGET-SITE BASED MECHANSIMS? C. Wu*[1], A. Perez-Jones[2], P. Feng[3], L. E. Flagel[1], S. S. Navarro[1]; [1]Bayer Crop Science, St Louis, MO, [2]Bayer Crop Science, Chesterfield, MO, [3]Bayer Crop Science, Saint Louis, MO (407)

ABSTRACT

METABOLIC RESISTANCE TO PRE-EMERGENCE HERBICIDES: THE CASE OF RYE-GRASS. R. Duecker[1], V. Brabetz[1], P. Zoellner[1], S. Ries[1], A. Collavo[1], P. Luemmen[1], R. S. Beffa*[2]; [1]Bayer Crop Science, Frankfurt, Germany, [2]Bayer Crop Science, Frankfort / Main, Germany (408)

ABSTRACT

Herbicides inhibiting the synthesis of very long-chain fatty acids (HRAC group K_3), such as flufenacet, play an important role in weed management strategies, particularly when herbicide resistance to inhibitors with other modes of action, such as ALS or ACCase, has already evolved. So far, only a few cases of resistance towards inhibitors of the synthesis of very long-chain fatty acids have been very long-chain. In this study, we have characterized the flufenacet resistance level in several *Lolium* spp. field populations and investigated the resistance mechanism.

The screening for flufenacet resistance revealed the ability of *Lolium* spp. populations from several continents to survive flufenacet treatments at and above the field rate. For the first time, this study demonstrates the way in which flufenacet is detoxified in resistant weed populations. Glutathione was found to be conjugated to flufenacet in *Lolium* spp. seedlings, and glutathione transferase activity was enhanced in protein extracts from flufenacet-resistant seedlings. A significant correlation was found between the resistance factor obtained by biotests and the degradation half-life of flufenacet in ryegrass plants obtained by HPLC. Transcriprome analyses showed that 11 GST gesnes are overexpressed in flufenacet resistant populations studied. Functional valdiation by expression of the recombinant protein of 4 genes in E.coli reveals that 1 gene encoding an active GST is able to detoxify flufenacet.

At present, flufenacet resistance is not widespread; however, in certain *Lolium* spp. populations resistance levels could reach agronomic relevance due to detoxification by glutathione transferases. In Europe especially, only a few herbicide modes of action are registered for the control of *Lolium* spp., and therefore it is becoming increasingly important to apply best management practices to limit further spread of flufenacet resistance.

COMPARISON OF *EPSPS* TANDEM DUPLICATION SEQUENCE ACROSS GLYPHOSATE-RESISTANT *KOCHIA SCOPARIA* POPULATIONS. T. Gaines*[1], E. L. Patterson[2], A. Dixon[3], C. Sparks[1], K. Ravet[1], A. Kuepper[4], P. Westra[1]; [1]Colorado State University, Fort Collins, CO, [2]Clemson University, Clemson, SC, [3]Rothamsted Research, Harpenden, England, [4]Bayer Crop Science, Frankfurt, Germany (409)

ABSTRACT

Glyphosate resistant kochia (*Bassia scoparia*) has been reported across the Great Plains, Intermountain West, Pacific Northwest, and the Canadian Prairie provinces since the first report in Kansas in 2007. Our objective was to ask whether glyphosate resistance evolved once in kochia and spread, or if multiple independent origins of glyphosate resistance occurred over time. We sampled kochia from 45 locations in eight US states and 1 Canadian province, and used 11 polymorphic Simple Sequence Repeat (SSR) markers developed from whole genome sequencing data. Results from the SSR data were inconclusive as to single or multiple origins of glyphosate resistance, as very high levels of within population genetic diversity were detected and no clear patterns of relatedness across populations were evident. In a separate approach, we assembled the duplicated genomic region containing the EPSPS gene. This revealed two types of repetitive units of different sizes, each containing EPSPS and several other genes, as well as a mobile genetic element-containing sequence inserted near the EPSPS gene. We used these sequence features as markers. Population analysis revealed that all southern Great Plains samples shared the same EPSPS repeat structure and mobile genetic element, while different patterns observed in kochia samples from northern Wyoming, Oregon/Idaho, and Canada suggested that independent origins of glyphosate resistance could be possible in each location.

METABOLIC RESISTANCE TO PREEMERGING HERBICIDES IN GRASSES: THE CASE OF BLACKGRASS. E. Parcharidou[1], R. Dücker[2], V. Brabetz[1], A. Kuepper[1], R. S. Beffa*[3]; [1]Bayer Crop Science, Frankfurt, Germany, [2]University of Göttingen, Frankfurt, Germany, [3]Bayer Crop Science, Frankfort / Main, Germany (410)

ABSTRACT

Black-grass (*Alopecurus myosuroides* Huds.) is a frequent grass weed that commonly occurs in winter wheat in temperate Europe. Evolving resistance to post-emergence herbicides *e.g.* ACCase and ALS inhibitors requires more complex weed management strategies and ensuring good efficacy of pre-emergence treatments becomes increasingly important. Flufenacet, in particular, has become a key herbicide for the control of multiple-resistant *A. myosuroides*. However, in some of those populations, reduced flufenacet efficacy was already observed.

In a screening of black-grass populations from several European countries, most populations were controlled with the registered field rate of flufenacet. However, differences in the level of flufenacet sensitivity were observed and correlated with glutathione transferase-mediated enhanced flufenacet metabolism. The efficacy of the pre-emergence herbicides pendimethalin, prosulfocarb, S-metolachlor and pethoxamid was also significantly decreased in populations with reduced flufenacet sensitivity. The use of flufenacet in mixtures with diflufenican, particularly in combination with flurtamone or metribuzin, however, significantly improved efficacy in less sensitive black-grass populations. Transcriptome analyses showed that five GST genes are overexpressed in the flufenacet resistant plants. These genes are different than those overexpressed in flufenacet resistant ryegrass populations analyzed previously.

In several populations of different European origins reduced efficacy of flufenacet was observed due to enhanced metabolism. Although differences between populations were relatively small, best weed management practices (*e.g.* application of full dose rates, herbicide mixtures and wide crop rotations) should be applied to reduce selection pressure and prevent flufenacet resistance from further evolving. This is particularly important as flufenacet is one of the few still effective herbicides suitable for the control of multiple-resistant *A. myosuroides* genotypes in Europe while alternative pre-emergence herbicides were less effective against multiple-resistant *A. myosuroides* populations.

AMBROSIA CONFERTIFLORA, A PERENNIAL INVASIVE WEED IN ISRAEL. B. Rubin*, Y. Yair; Hebrew University of Jerusalem, Rehovot, Israel (411)

ABSTRACT

Five *Ambrosia* species are currently identified in Israel in various phases of invasion. The invasive *Ambrosia confertiflora* DC; Three naturalized species: *A. tenuifolia* Spreng, *A. psilostachya* DC and *A. grayi* (A. Nelson) Shinners, and the casual species *A. artemisiifolia* L.. These *Ambrosia* species are known throughout the world as invasive, allergenic, and noxious weed. *A. confertiflora* was first recorded in Israel at 1990 and underwent a population explosion in less than 15 years. *A. confertiflora* spreads by both rhizomes and viable seeds that can germinate after two days and remain viable for a long period. Optimal germination and emergence occur when seeds are on the soil surface, and no emergence detected below 4cm depth. Seed germination rate and below-ground organs biomass production decreases when temperatures are high, while above-ground biomass increases. At low temperatures, a rosette is formed that covers the soil surface while mostly rhizomes develop underground. When the temperature rises, the plants elongate quickly, achieving an advantage in the competition for sunlight and getting a better opportunity to disperse pollen and seeds. Extracts of pollen grains collected from flowering plants were tested for allergenic potential by *skin* prick *test* on 163 volunteers in two hospitals. The participant's response to *skin*

prick *test* was stronger to *A. confertiflora* (17%) pollen extract as compared to pollen extracts of *A. tenuifolia* (8%), *A. artimisiifolia* (5%) and *A. trifida* (3%). Due to *A. confertiflora* wide distribution and prolific growth under different environmental conditions, it poses a continuous threat to the farming systems and environment as well as to public health.

NEW INSIGHT ON THE MECHANISM OF ACTION OF PPO INHIBITORS. F. E. Dayan*, A. L. Barker; Colorado State University, Fort Collins, CO (412)

ABSTRACT

PPO inhibitors were commercialized in the 1960s for weed control in soybean. Several non-diphenyl ether herbicides based on the triazolinone and the oxadiazole structures have been registered for weed control in cereal crops. Compounds with the highest biological activity, such as oxyfluorfen and azafenidin, have also been developed for use as nonselective herbicides in noncrop areas and nurseries. Interest in PPO inhibitors waned in after the introduction of glyphosate-resistant crops in the mid-90s but resumed in the last 5-6 years, as a great tool to manage glyphosate-resistant weeds. While a number of weeds have evolved resistance to post-emergent application of PPO inhibitors, a number of compounds with this mode of action have retained preemergence activity. In the interest of preserving the usefulness of this chemistry to manage difficult to control weeds, we investigated the factors differentiating pre and post activity of this class of herbicide. The mode of action of PPO inhibitors is complex because plants have two isoforms of this enzyme, one involved in chlorophyll synthesis in chloroplasts and another involved in heme synthesis in both the mitochondria and chloroplasts. Both of these enzymes are inhibited by PPO but their relative contribution toward the accumulation of protoporphyrin responsible for the toxicity of this class of herbicides is not understood. These differences will be discussed.

MECHANISMS CAUSING 2,4-D RESISTANCE IN *SONCHUS OLERACEUS*. M. Krishnan*[1], T. Petrovic[2], A. Merriam[2], G. Velappan[2], C. Preston[2]; [1]University of Adelaide, Urrbrae, Australia, [2]University of Adelaide, Glen Osmond, Australia (413)

ABSTRACT

Common sowthistle is an emerging problematic weed in fallows and legume crops in Australia. Having already evolved resistance to ALS herbicides and glyphosate, an increasing reliance upon Group 4 herbicides has now given rise to resistance to 2,4-D and similar auxinic herbicides. In our studies, we have identified 3 populations of sowthistle from irrigation circles and confirmed 2,4-D resistance through dose response experiments. Initial findings suggest the resistance is inherited in a dominant mode and is not caused by P450-mediated detoxification.

GLYPHOSATE-RESISTANT *ECHINOCHLOA COLONA* FROM MISSISSIPPI AND TENNESSEE: MAGNITUDE AND RESISTANCE MECHANISMS. V. K. Nandula*[1], G. Montgomery[2], A. Vennapusa[3], M. Jugulam[3], D. Giacomini[4], J. Ray[5], J. A. Bond[6], P. Tranel[7]; [1]USDA-ARS, Cleveland, MS, [2]University of Tennessee, Knoxville, TN, [3]Kansas State University, Manhattan, KS, [4]University of Illinois, Urbana, IL, [5]USDA, Stoneville, MS, [6]Delta Research and Extension Center, Stoneville, MS, [7]University of Illinois, Urbana, IL (414)

ABSTRACT

Recently, several incidents of glyphosate failure on junglerice [*Echinochloa colona* (L.) Link] have been reported in the midsouthern United States, specifically in Mississippi and Tennessee. Research was conducted to measure the magnitude of glyphosate resistance and to determine the mechanism(s) of resistance to glyphosate in *E. colona* populations from Mississippi and Tennessee. ED_{50} (dose required to reduce plant growth by 50%) values for a resistant MSGR4 biotype, a resistant TNGR population, and a known susceptible MSGS population were 0.8, 1.62, and 0.23 kg ae ha^{-1} of glyphosate, respectively. The resistance index calculated from the these ED^{50} values indicated that the MSGR4 biotype and TNGR population were 4- and 7-fold, respectively, resistant to glyphosate relative to the MSGS population. The absorption patterns of [^{14}C]glyphosate in the TNGR and MSGS populations were similar. However, the MSGS population translocated 13% more [^{14}C]glyphosate out of the treated leaf compared with the TNGR population at 48 h after treatment. *EPSPS* gene sequence analyses of TNGR *E. colona* indicated no evidence of any point mutations, but several resistant biotypes, including MSGR4, possessed a single-nucleotide substitution of T for C at codon 106 position, resulting in a proline-to-serine substitution (CCA to TCA). Results from quantitative polymerase chain reaction analyses suggested that there was no amplification of the *EPSPS* gene in the resistant populations and biotypes. Thus, the mechanism of resistance in the MSGR population (and associated biotypes) is, in part, due to a target-site mutation at the 106 loci of the *EPSPS* gene, while reduced translocation of glyphosate was found to confer glyphosate resistance in the TNGR population.

RESISTANCE TO CLETHODIM IN ITALIAN RYEGRASS (*LOLIUM PERENNE* SSP. *MULTIFLORUM*) FROM MISSISSIPPI AND NORTH CAROLINA. V. K. Nandula*[1], D. Giacomini[2], B. Lawrence[3], W. Molin[4], J. A. Bond[5]; [1]USDA-ARS, Cleveland, MS, [2]University of Illinois, Urbana, IL, [3]Mississippi State University, Stoneville, MS, [4]USDA-ARS, Stoneville, MS, [5]Delta Research and Extension Center, Stoneville, MS (415)

ABSTRACT

Clethodim, an acetyl-CoA carboxylase (ACCase)-inhibiting herbicide, is one of the few postemergence chemical control options available to growers of Mississippi to manage glyphosate and/or other herbicide resistant Italian ryegrass populations. Recently, clethodim failed to adequately control Italian ryegrass populations across Mississippi. A sethoxydim, also an ACCase inhibitor, -resistant Italian ryegrass population from North Carolina was cross-resistant to clethodim. This research characterized magnitude and mechanisms of clethodim resistance in the Mississippi and North Carolina Italian ryegrass populations. Two clethodim-resistant biotypes from Mississippi, MS24 and MS37, were 10- and 4-fold resistant, respectively, relative to a susceptible (SUS1) biotype. A North Carolina biotype, NC21, was 40-fold resistant to clethodim compared to SUS1. Two additional biotypes from North Carolina, NC22 and NC 23, recorded shoot dry weight reduction of only 17 to 30% of nontreated at the highest clethodim dose of 2.17 kg ha^{-1}, (8X). The NC22 biotype was cross-resistant to sethoxydim, fluazifop, quizalofop, and pinoxaden. The MS37

biotype had three target site mutations, I2041N, C2088R, and G2096A. Another clethodim-resistant biotype from Mississippi, MS51, had only the C2088R substitution. The NC22 and NC23 biotypes had I1781L, I2041N, and D2078G replacements. This study shows that the mechanism of resistance to clethodim in Italian ryegrass from Mississippi and North Carolina is due to target site modifications in the *ACCase* gene leading to broad cross-resistance to other ACCase-inhibiting herbicides.

PALMER AMARANTH AND KOCHIA IMPACTS AND RESEARCH IN COLORADO. P. Westra*[1], T. Gaines[1], E. L. Patterson[2], A. Effertz[3]; [1]Colorado State University, Fort Collins, CO, [2]Clemson University, Clemson, SC, [3]Colorado State University, Ft. Collins, CO (416)

ABSTRACT

WHAT CAN DRIVE RESISTANCE TO CHLOROACETAMIDES IN AMARANTHUS? N. R. Burgos*[1], G. Rangani[1], L. Benedetti[2], R. A. Salas-Perez[1]; [1]University of Arkansas, Fayetteville, AR, [2]Universidad Federal do Pelotas, Pelotas, Brazil (417)

ABSTRACT

HELPING FARMERS NAVIGATE COMPLEX DECISIONS ABOUT MANAGING WEEDS IN ORGANIC SYSTEMS. D. Doohan*[1], D. Bessette[2], C. Beaudrie[3], S. Culman[4], R. Wilson[5]; [1]Ohio State University, Wooser, OH, [2]Michigan State University, East Lansing, MI, [3]Compass Resource Management Ltd., Vancouver, BC, [4]Ohio State University, wooster, OH, [5]Ohio State University, Columbus, OH (418)

ABSTRACT

Managing weeds continues to be one of the top concerns of organic farmers, despite research and demonstrations of effective ecological weed management (EWM) approaches. Reasons that farmers continue to struggle with weed control include the challenges of making solutions developed at public research institutions work consistently in real-life circumstances and the typical lower efficacy of ecological approaches. We developed a decision support framework (DSF) to address a third complication often overlooked, i.e., navigating the trade-offs among weed control, quality of life, financial, and soil quality goals when tillage and cultivation are the primary methods used. The DSF, found at organicweedmanager.com, links estimated performance of EWM strategies to farmer values and facilitates thoughtful tradeoffs when those values conflict. Development of the DSF included expert elicitations with university-based specialists as well as a group of organic farmers. Upon entering the DSF, users respond to a series of questions about their soils, crops grown, and rotation, tillage, fertilization, and weed control practices, including those practices' perceived effectiveness and costs. Previous research indicated farmers were especially concerned about the potential for excessive tillage and cultivation to adversely affect soil quality; therefore, questions about soils focus on organic matter and soil physical parameters. Responses allow one to visually compare their own practices to a 'common strategy', a 'critical stage weed management' strategy, and a 'seedbank elimination strategy'; the latter composed of a suite of 'short-term' practices required from years 1-4 and a smaller suite of long-term practices that would be required from year 5 and beyond. The DSF then ranks and displays the impact of the users' practices on soil health and weed control costs and compares those impacts to those of other strategies. The session continues by enabling the user to explore the interplay between their values and the various weed control strategies including their own. The final screens provide advice on practices to start, to continue, and to stop based on the results of the DSF and the users' preferences. To date the DSF has been trialed with about 50 organic farmers, mostly from the North Central region, critically examined by our team members, and presented at a number of farmer conferences. While more work is needed before this DSF is ready for the street, feedback so far indicates that the tool is very effective in helping farmers think about the relationship between their goals and values, and the weed control practices they use.

COMPLEMENTARY APPLICATIONS OF ANALYTIC TECHNIQUES IN FIELD RESEARCH. J. T. Buol*[1], A. Brown-Johnson[2], D. B. Reynolds[1]; [1]Mississippi State University, Mississippi State, MS, [2]Mississippi State Chemistry Laboratory, Mississippi State, MS (419)

ABSTRACT

Complementary applications of analytic techniques in field research.

JT Buol, AE Brown-Johnson, DB Reynolds

Continued developments in analytic chemistry have led to refined or novel techniques for analyzing samples of various media important in agriculture such as soil, plant tissue, solutions, and captured air. Knowledge of the availability and capability of these analytic techniques among field scientists is often limited to those with previous experience or training in analytic chemistry. An improved awareness and basic understanding of available analyses and analytic approaches may help inform future research endeavors and refine research questions and objectives in weed science and agricultural research in general. This work presents information regarding the availability of and basic concepts behind various techniques in analytic chemistry and how they may be (and are) applied to agricultural research. Key principles and terminology regarding chromatography and spectrometry/spectroscopy are discussed, with in-depth explanation of the processes underlying each technique provided. An overview behind the mechanics of HPTLC, HPLC/MS, GC/MS, IR spectroscopy, ICP-OES/MS, and fluorescence spectroscopy is presented, and current applications of these techniques in published and ongoing agricultural research are highlighted. There are many more analytic techniques available to support and augment applied agricultural research than are discussed here. Future graduate curricula and training programs for agricultural scientists should seek to go beyond topical discussion of molecular biology and include an emphasis on analytic chemistry techniques. Increasing the interface between applied and analytic techniques in agricultural research will be pivotal towards maximizing research potential in the future.

PREDATORY PUBLISHING: WHERE ARE WE NOW? S. M. Ward*; Colorado State University, Fort Collins, CO (420)

ABSTRACT

The landscape of scholarly publishing has changed dramatically with the rise of online open access journals and the accompanying shift from subscriber to author as primary revenue source. Predatory journals charge author fees to publish articles online with little or no peer review, and no guarantee of archiving, indexing, or other editorial services. Predatory publication increased from approximately 53,000 articles in 2010 to over 420,000 articles in 2014, with a current worldwide estimate of at

least 8,000 predatory journals. A 2013 study suggested that authors publishing in predatory journals were mostly early-career scientists from developing countries with limited resources. However, a 2017 survey of 1,907 papers from 200 biomedical journals categorized as predatory found that 16% of the corresponding authors were from the United States. Whether authors are knowingly publishing in predatory journals, or lack information to recognize them, requires further investigation. Predatory journals are using more sophisticated techniques to attract authors, including deceptive mirroring of legitimate journal titles, claiming fake impact factors and indexing services, and listing well-known scientists as editorial board members without their knowledge or permission. Proposed requirements for open access publication of publicly-funded research, for example the "Plan S" initiative in Europe, could further complicate scholarly publishing in the near future.

HOW CAN WEED SCIENTISTS ADDRESS THE CALIFORNIA GLYPHOSATE VERDICT? J. D. Byrd, Jr.*; Mississippi State University, Mississippi State, MS (421)

ABSTRACT

Views expressed in this abstract do not reflect those of Mississippi State University, Mississippi State University Extension Service, Mississippi Agriculture and Forestry Experiment Station, nor the Department of Plant & Soil Sciences. This author is not an oncologist, toxicologist, physician, lawyer, nor expert as it pertains to pesticide safety.

In 2018, a California civil court jury awarded $289 million US dollars to a San Francisco school groundskeeper who claimed non-Hodgkin lymphoma cancer was the result of his exposure to Monsanto's Roundup while he was required to apply the herbicide to school property from 2012 to 2015. While weed scientists have no expertise regarding medical issues, public as well as private agencies and individuals look to weed scientists at land grant institutions to provide information, including glyphosate safety following the press release of this verdict and subsequent advertisements by lawyers trolling for class action law suits. Three practical responses should be part of the answer to concerned individuals: 1) despite the medical studies presented into evidence, a cause and effect relationship between glyphosate and any form of cancer has never been **proven**; 2) far more studies have been published by a more diverse group of medical experts that indicate no potential human health danger associated with glyphosate exposure other than that of eye irritation, which is clearly stated on the label; 3) groundskeepers by occupation are exposed to a number of compounds listed in California Proposition 65 that are also strongly correlated with cancer, including gasoline, gasoline emissions, gasoline vapors, oil, diesel exhaust fumes, and carbon.

A CROPPING-SYSTEM WEED SCIENCE SURVEY OF BRAZIL, A BREADBASKET COUNTRY IN THE TROPICS. M. Coura Oliveira*[1], A. Lencina da Silva[2], A. R. Ulguim[2], R. Werle[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]Universidade Federal de Santa Maria, Santa Maria, Brazil (422)

ABSTRACT

Brazil is a top producer of cereal, fiber, ethanol, and fruits in the tropics. From April to June of 2018, an online survey (via Qualtrics) containing 38 questions related to cropping-systems and weed management was conducted with 345 Brazilian stakeholders. The objective of the survey was to understand from Brazilian farmers and decision influences (crop consultants, and coop, industry, and university representatives) their agricultural practices and perceptions. Seventy-three and 66% of survey respondents manage soybeans and corn, respectively, the largest crops produced in the country. Approximately 75% of respondents grow or manage annual cropping systems with two to three crops cultivated per year, including soybeans, corn, cotton, wheat, and/or dry beans. Fifty percent of respondents manage rainfed cropping-systems, and over 75% of respondents use no-tillage as a standard practice. According to respondents, the top five troublesome weed species of Brazil are *Conyza* spp., *Digitaria insularis*, *Ipomoea* spp., *Eleusine indica*, and *Commelina benghalensis*, respectively. Amongst the eight species that have evolved resistance to glyphosate in Brazil, *D. insularis* and *Conyza* spp. are the most concerning according to survey participants. Other than glyphosate, 25 and 75% of respondents manage ACCase- and ALS-inhibitor resistant weeds, respectively. Besides herbicides, 50% of respondents use mechanical, and 75% use cultural weed control strategies. Sixty-one percent of survey respondents use cover crops to suppress weeds and improve soil chemical and physical properties. Nearly 90% of survey respondents intend to some extent adopt the Xtend (Dicamba) and Enlist (2,4-D) technologies when available in the country. When asked about the biggest challenges pertaining to weed management in Brazil, respondents ranked weed resistance, weed control costs, and herbicide selectivity as the top three concerns. According to 54% of survey respondents, industry representatives are the main source for weed management information and recommendations. Here, we present an overview of crop and weed management practices adopted and challenges faced in Brazilian agriculture. Results presented herein might aid Brazilian stakeholders to understand the bad and good on current agricultural and weed management practices and fine-tune their systems moving forward.

SURVEY OF 2017 AND 2018 DICAMBA USE IN NEBRASKA AND WISCONSIN SOYBEAN PRODUCTION SYSTEMS. R. Werle[1], A. J. Jhala[2], P. D. Mitchell[1], M. Coura Oliveira*[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]University of Nebraska-Lincoln, Lincoln, NE (423)

ABSTRACT

Due to off-target dicamba movement incidents during the 2017 and 2018 growing seasons, adoption of the Xtend technology (dicamba and glyphosate-tolerant soybeans) has become a controversial topic in the United States. From August through September of 2018, a survey containing 22 questions related to soybean, dicamba and weed management was conducted with 316 and 149 stakeholders from Nebraska and Wisconsin, respectively. The objective of the survey was to understand Nebraska and Wisconsin stakeholders' adoption and opinion related to the Xtend technology. Respondents were grouped into two categories: i) growers and ii) decision influencers (agronomists, coop, industry and university representatives). According to growers, in 2018, 53 and 31% of their managed hectares were planted with Xtend soybean cultivars in Nebraska and Wisconsin, respectively. In 2019, they expect to increase the Xtend soybean hectares in 11 and 17% in Nebraska and Wisconsin, respectively. According to growers and decision influencers from Nebraska, 42% of Xtend soybean hectares were sprayed PRE and nearly 65% POST. In Wisconsin, <25% and 45% of Xtend hectares were sprayed with dicamba PRE and POST, respectively. In Nebraska, over 90% of respondents use/recommend an effective PRE-herbicide program with multiple site(s)-of-action (SOA) whereas in Wisconsin approximately 75% do. Weed management improved with the adoption of the Xtend soybean technology according to >80% respondents from Nebraska; in Wisconsin, improvement in weed control was reported by 66% of growers and 75% of decision influencers. Approximately 75% of Nebraska and Wisconsin growers who participated in this survey own a sprayer and spray their herbicide programs. All Nebraska and Wisconsin respondents that sprayed dicamba in Xtend soybeans in 2018 used a labeled formulation (i.e., Engenia, FeXapan, or XtendiMax). Less than 10% of survey respondents from Nebraska and Wisconsin reported that their dicamba application in Xtend soybeans injured neighboring sensitive soybeans. However, nearly 50% (Nebraska) and 20% (Wisconsin) of respondents (growers and decision makers) noticed dicamba injury on their non-Xtend soybeans. Three percent of growers from Nebraska filed an official off-target dicamba complaint with the Department of Agriculture; Wisconsin respondents that observed injury on their non-Xtend soybeans did not file an official complaint. When asked the main cause for dicamba injury on non-Xtend soybeans, physical drift and volatilization from dicamba either applied in Xtend soybeans or corn (e.g., Status) were the main answers in both states. Here we present a summary of the adoption of Xtend technology in two distinct states. Faster adoption of the technology in Nebraska is likely due to more significant challenges faced with the widespread presence of herbicide-resistant weeds when compared to Wisconsin. In general, Nebraska and Wisconsin growers tended to be more conservative in their answers than decision influencers. These survey responses will aid growers, and decision influencers understand current and future adoption of the Xtend technology in the upper Midwest.

EVALUATING MANY SIDES OF AN ISSUE: TEACHING WITH CASE STUDIES. A. Dille*; Kansas State University, Manhattan, KS (424)

ABSTRACT

Students graduating with a degree in Agronomy are usually technically sound, but employers are looking for graduates that also have soft skills, such as critical-thinking, written and oral communication, problem solving, ability to work in a team, and leadership capabilities. The Agronomy curriculum at Kansas State University requires students to complete a capstone experience, which could be a study abroad experience or a specific course. In the Agronomy Capstone Experience course (AGRON 602), many different approaches are used to develop and evaluate the soft skills that our Agronomy seniors need to have. One approach is the use of case studies, whereby students will role-play different perspectives around an issue and present these orally in a town hall meeting environment. If the students are not role-playing, they then participate as town hall audience members. To be ready for the town hall meeting, all students are reading a common set of background papers and responding to questions. The students representing certain perspectives have specific readings and questions that they must prepare beforehand for the town hall meeting. Three different case studies are used in the Agronomy Capstone Experience course with an enrollment of 20 to 22 students. One case is trying to discern why water quality of a stream changed between sampling events and whose fault is it. A second case is understanding the impact of not keeping identity preserved grain out of the human food chain. A third case involves understanding non-target impacts because of the use of pesticides. Depending on the case, students might represent land owners, neighbors, chemical sales representative, an agronomist, a consumer, fisheries biologist, or beekeeper. Students are evaluated on their responses to the readings and questions, their ability to discuss and refute statements by the other representatives, and how they respond to questions from the audience. In the end, students learn to appreciate the fact that there is no clear right or wrong answer within these case studies, but that multiple sides and perspectives are shared, and can be done in a civil manner.

MILLIONS OF PEOPLE, MILLIONS OF ACRES: CO-EXISTING IN A BIG AG, BIG URBAN STATE. J. Payne*[1], T. Mueller[2]; [1]Illinois Fertilizer and Chemical Associatino, Bloomington, IL, [2]University of Tennessee, Knoxville, TN (425)

ABSTRACT

In a state that ranks #1 in soybean production and #2 in corn, big agriculture rules. Or rather, it used to. The fact that Illinois also ranks high on the list in terms of nutrient and pesticide use poses a challenge with our increasingly urban population and the legislators who represent them. Did I mention that 95% of our corn and soy crops are also genetically modified? In a world where it's becoming socially unacceptable to feed your children anything but organic, and you are encouraged to feed your dog non-GMO food, does anyone see a problem brewing for a state like Illinois?

We aren't California yet, but we are on the precipice. What will it take to tip the scales and turn Illinois into the California of the Midwest? Give me a "D" .....

In the 1990s when I was learning how to be good ag lobbyist, I was advised to "be sure to stand in the back of the hearing room where the legislators can see you—if any discussions start trending anti-agriculture, they will call you up so you can squash it." For a few decades, this worked. Every time. But those days have past. We aren't sure when it changed, but it has changed.

On the surface, Illinois agriculture looks to have things under control. But below the surface it has taken a courageous and often uncomfortable effort to build alliances with historic adversaries, give when we used to take, pay our own way and sit at the table vs standing in the back of the room. "Telling our story" doesn't get you very far. But accepting our vulnerabilities, being honest about our challenges and compromising does. In other words: co-existing and finding the middle ground. In the 1990's considerations such as these would have elicited gasps of disbelief and be grounds for ag lobbyists to thrive. Can we do it? Is there middle ground? Some think not. They would be wrong.

SOCIETAL DEVELOPMENTS AND EXPECTATIONS IN EUROPE &NDASH; IMPLICATIONS ON ENVIRONMENTAL REGULATION OF AGRICULTURE. J. Keppler*[1], T. Mueller[2]; [1]Bayer Crop Science, Frankfurt/Main, Germany, [2]University of Tennessee, Knoxville, TN (426)

ABSTRACT

Within the last century, Europe experienced a tremendous increase of productivity in agriculture. The introduction of synthetic fertilizers and plant protection products along with significant progress made in crop breeding and farm mechanization resulted in more than 4fold yield increases for key crops like cereals since 1900. Taking Germany as densely populated industrial country as an example, the percentage of people working in agriculture dropped from 38 % in 1900 to 1,4 % today while the spends for food decreased on average from 55% of the income to 14 % today within the same time period. Today, the share of agriculture in the gross national product in Germany is 0.9 %; statistically, one farmer produces food to feed 149 people and a significant share of the overall consumed food is imported from all over the world.

As a consequence of these key trends and developments, increasing disconnects between large parts of the society and the agricultural community in European countries like Germany can be observed. The vast majority of the population is no longer exposed to food production and not familiar with the agricultural context. The relevance and benefits of European agriculture for food supply and security plays no major role in general education and public or societal debates. Although highly regulated since many years, particularly the use of plant production products is increasingly questioned and criticized. The European Regulation 1107/2009 concerns the placing of plant protection products on the EU market with the objective to "*ensure a high level of protection of both human and animal health and the environment and at the same time safeguard the competitiveness of Community agriculture*". The ongoing definition of protection goals and the translation of Regulation 1107/2009 into detailed environmental Guidance Documents results in increasingly complex risk assessment approaches. Examples of currently discussed future requirements for herbicides and the need to put them into the broader agricultural context will be presented and discussed.

OUR LAND AND WATER; PERSPECTIVES ON HOW MARKET FORCES AND REGULATION ARE SHAPING THE FUTURE OF NZ FARMING. R. Dynes*[1], T. Mueller[2]; [1]New Zealand Ag Research, Christchurch, New Zealand, [2]University of Tennessee, Knoxville, TN (427)

ABSTRACT

Agriculture and its allied industries remain the major contributors to New Zealand's export economy and has grown over the last 25 years through both intensification and land use change. However increasing urbanization and concern for the environment are placing farming and farming practices under increasing scrutiny and

'social license to farm' is now a challenge to these practices. New Zealand's National Policy Statement on Fresh Water sets expectations for water quality in NZ and must be implemented and regulated at a regional level. New Zealand farming sector faces multiple pressures which are both shaping farming systems and creating momentum for transformational change. This presentation will explore drivers of change, the role of policy and the opportunities for the farming sector.

RESTRICTIONS TO FARMING IN THE PACIFIC NORTHWEST, FROM ENDANGERED SALMON RUNS TO IMPACTS FROM URBAN GARDENS. T. W. Miller*[1], T. Mueller[2]; [1]Washington State University - Mt Vernon, Mount Vernon, WA, [2]University of Tennessee, Knoxville, TN (428)

ABSTRACT

Washington state was ranked #11 in terms of agricultural cash receipts in 2017 (USDA). Agriculture production ranges across several climatic zones in the state, from temperate rain forests along the western coast, to non-irrigated berry and vegetable crop production in much of western Washington, to dryland cereal production in eastern Washington, to the semi-arid irrigated agriculture in the Columbia Basin of central Washington. Nearly the entire state is drained by the Columbia River and its tributaries, which stretches into Idaho, Montana, Oregon, and Wyoming, and much of southern British Columbia. Listing of several runs of anadromous Pacific salmon species by USEPA in the late 1990s resulted in changes of water availability for agriculture and other uses throughout the region. Concerns regarding agricultural runoff and leaching of farm chemicals are constantly discussed by the public, resulting with legislation mandating buffers near streams and restrictions on the quantity and timeliness of surface and subsurface water availability. Additionally, as in many states, Washington growers face increasing resistance to farming practices due to urban growth in agricultural areas, ranging from odor abatement, to pesticide drift concerns, to reservoirs of insect and plant disease pathogens residing in garden areas. Recently, pollen flow from overwintering kale and other vegetables in Brassicaceae growing in urban gardens has directly threatened the continued viability of commercial Brassica seed production in northwestern Washington. These and other threats to agriculture in Washington will be discussed during this Symposium session.

EDUCATIONAL EXPERIENCE AT CORTEVA AGRISCIENCE WESTERN RESEARCH CENTER, FRESNO, CALIFORNIA. D. Saha*[1], J. Armstrong[2], C. Marble[3]; [1]Mid-Florida Research and Education Center, University of Florida, Apopka, FL, [2]Corteva Agriscience Western Research Center, Fresno, CA, [3]University of Florida, Apopka, FL (429)

ABSTRACT

The educational experience at Corteva Agriscience Western Research Center (WRC), Fresno, California was for five days and four nights. Corteva Agriscience WRC has a 52-year-old farm, which is 65 ha in size where company scientists conduct field trials for new crop protection products. Current ongoing projects include 1) pesticide trials on cotton (*Gossypium hirsutum* L.), melons (*Cucumis melo* L.), broccoli (*Brassica oleracea* L. var. *botrytis*), and cabbage (*Brassica oleracea* L. var. *capitata*) for controlling aphids and other arthropod pests; 2) Evaluation of pesticides to manage thrips in peach [*Prunus persica* (L.) Batsch] orchards; and 3) Evaluation of pesticides for managing powdery mildew in cucurbits. Corteva Agriscience WRC has several modern and updated farm machineries including an air blast sprayer, an orchard sprayer or herbicide rig (containing a 152 cm long spray boom), and several large tractors for tilling the dry soil of Fresno. The local farming in Fresno consisted mostly of almond (*Terminalia catappa* L.), pistachios (*Pistacia vera* L.), grapes (*Vitis vinifera* L.), peaches, and walnuts (*Juglans regia* L.). Almond production was the highest among all other crops because of the Mediterranean type climate. Italian ryegrass (*Lolium perenne* L.), junglerice [*Echinochloa colona* (L.) Link], hairy fleabean [*Conyza bonariensis* (L.) Cronquist], barnyard grass [*Echinochloa crus-galli* (L.) P. Beauv], and yellow nutsedge (*Cyperus esculentus* L.) were some of the common weeds in their orchard systems. Many of these weeds were glyphosate resistant and currently controlling them has become a major issue for the local growers. Fresno's natural vegetation also includes the beautiful Yosemite Valley, which consists of granite mountains, beautiful waterfalls, lakes, and giant sequoia trees. The Mariposa Grove at Yosemite Valley consists of majestic giant sequoia trees. Some of these trees were 2800 years old with 61 meters deep root system and very resistant to forest fires. Overall, this educational experience was unique as it has allowed the graduate students to travel, interact and work with different weed scientists in other regions of the country and has helped them to shape their future career to become a successful weed scientist.

WE'RE NOT IN ROW CROPS ANYMORE: A BOILERMAKER'S TALE OF CALIFORNIA AGRICULTURE. C. McCauley*; Corteva Agriscience, Indianapolis, IN (430)

ABSTRACT

As one of the fortunate recipients of the WSSA Graduate Student Travel Experience award, I was able to gain first-hand knowledge of west coast agriculture. In August 2018, I traveled to Davis, California to begin my weeklong tour of Central Valley crop production with Dr. Brad Hanson. With nearly 400 crops grown in varied geography throughout the state, my goal of the experience was to learn more about the complexity of their cropping systems and to understand the weed management challenges specific to each crop.

First, I experienced the "best place in the world to grow strawberries," Salinas, CA, with Dr. Steve Fennimore during harvest and visited fields of other coastal crops such as artichokes, broccoli, and celery. On a farm call with Dr. Lynn Sosnoskie in Fresno, I discovered the challenges of managing weeds in almond and pistachio orchards. Next, I observed herbicide drift on a vineyard and spoke with farmers on the loss to their 30 year investment of Old Zinfandel grapes. On the final day, I traveled north to Biggs, CA with Dr. Kassim Al-Khatib to tour the California Rice Research Station and a lavender farm.

Exposure to the agronomic, and more specifically the weed management, challenges outside of corn and soybean during this experience was incredible. I gained an appreciation for the complexity of diverse cropping systems and how limitations of hand labor and water availability affect production throughout the growing season. This was an amazing week of education and exploration, I whole-heartedly thank all who contributed their time to my adventure and encourage all graduate students to apply for this opportunity.

2018 WSSA TRAVEL ENRICHMENT EXPERIENCE WITH THE UNIVERSITY OF GEORGIA AT TIFTON. J. Gizotti de Moraes*; University of Nebraska-Lincoln, North Platte, NE (431)

ABSTRACT

During the year of 2018 I had the great opportunity to spend six days in Georgia to better understand the weed management practices in a different region. I am so glad and honored for the amazing experience I have had. Originally from Brazil, I have been always amazed by the diversity we can find when working with agriculture. The reason why I chose to have this travel enrichment experience in a unique state where agriculture is truly diverse. The first three days I spent with Dr. Prostko who is responsible for the state-wide extension weed science programs for peanut, field corn, soybean, grain sorghum, sunflower, canola, and sesame. Besides visiting research plots and local farms, I also had the opportunity to understand how Extension Specialists and County Agents work together; the importance of disseminating research-based information to the agents across the state. The last three days I spent with Dr. Culpepper who is an Extension Agronomist working with cotton, vegetable and small grain. I had the opportunity to interact with his team, to help his students on their research projects, and to visit vegetable, tobacco and cotton producers. During these six days I could learn more about the weed management practices in peanuts, pecans, blueberries, blackberries, vegetables, tobacco, cotton, soybean, and corn. Moreover, I could experience the life of two Extension Specialists; the phone calls received all day long, their hard work spraying plots, collecting data, visiting/meeting with growers and county agents, or even driving a tractor. I could witness the passion for developing information to keep the growers profitable.

TRAVEL ENRICHMENT EXPERIENCE: HERBICIDE RESISTANCE IN THE MISSISSIPPI DELTA AND BEYOND. S. C. Haring*; University of California, Davis, Davis, CA (432)

ABSTRACT

Agricultural systems are uniquely tied to place and people. A broad understanding of weed science relies on understanding of not just chemistry and ecology, but also of the diverse landscapes and peoples that shape agriculture. I was fortunate to broaden my perspective of agriculture in the United States by shadowing Dr. Frank Carey through the WSSA Travel Enrichment Experience. Dr. Carey is a field market development specialist for Valent USA, and I experienced a portion of his role in field pesticide development and as research center manager. Although I stayed in a suburb of Memphis, TN, we covered nearly 2000 miles during the weeklong visit. We traveled extensively through the Mississippi Delta but also through Arkansas, northern Louisiana, and central Mississippi, to look at many aspects of rice, soybean, cotton, and other agronomic crops. Herbicide resistance is a major concern in this region, including both resistant weeds and new resistant crop technologies, though no singular research or management issue dominated our discussions. I was struck by the breadth of knowledge required to work with researchers, growers, and colleagues in this space, and this experience highlighted the importance of professional skills like the ability to work across pest management disciplines and cropping systems. I also waded into a rice field for the first time, to the chagrin of my peers in California. Many thanks to Dr. Carey and the people who facilitated this experience, and to the WSSA for paying travel costs in advance rather than reimbursing costs later.

SURVEYING SYNGENTA IN GREENSBORO, NORTH CAROLINA. J. J. Puka-Beals*; North Dakota State University, Fargo, ND (433)

ABSTRACT

Exposure to private sector work environments is important to the development of a well-rounded agricultural science student. In traveling to Greensboro North Carolina, I sought to understand what Syngenta researchers felt were the most concerning and exciting developments in agricultural science. Herbicide resistance was cited as a primary concern. The development of new weed control tools and precision agriculture were cited as exciting developments. I was not expecting the degree of collaboration I observed both between private sector companies and with public sector researchers during my time at Syngenta. I was hosted by Carroll Moseley and am deeply grateful for the experience.

CAROLINA REDROOT (*LACHNANTHES CAROLINIANA*) GROWTH AND RHIZOME PRODUCTION RESPONSE TO ENVIRONMENTAL CONDITIONS. T. E. Besancon*; Rutgers University, CHATSWORTH, NJ (434)

ABSTRACT

The perennial nature of cranberry (*Vaccinium macrocarpon* L.) crop predisposes it to a diversity of weed species ranging from herbaceous weeds to woody perennial species, including Carolina redroot [*Lachnanthes caroliniana* (Lam.) Dandy] in New Jersey. Carolina redroot is a perennial herbaceous weed species belonging to the *Haemodoraceae* family. It competes for nutritional resources during the cranberry growing season, and its rhizome serve as a feeding resource for wintering waterfowl that can cause severe uprooting damages of cranberry vines when bogs are flooded. Knowledge of weed propagation mechanisms and how environmental factors may affect them remains a critical aspect of any integrated weed management program. This is especially true in cranberry production, which relies on specific cultural practices, such as sanding or flooding, that can help suppress weed emergence and development. Therefore, a greenhouse study was conducted in 2018 at the Rutgers University PE Marucci Center for Blueberry and Cranberry Research and Extension, Chatsworth, NJ, to determine the effects of various environmental factors on Carolina redroot vegetative and rhizomatic growth. The effects of planting depths (0.5, 1, 2, 4, 8, and 16 cm), soil moisture content (5, 10, 20, 30, 40, 50, and 60% of soil water-holding capacity), rhizome water content (100, 75, 50, and 30% water content), rhizome flooding duration (15, 30, 60, 120, and 180 days), and light conditions (12h day light versus complete darkness) on Carolina redroot development were evaluated by assessing daily shoot emergence as well as plant height, above- and belowground biomass 45 days after planting. Data were analyzed with NLMIXED procedure in SAS 9.4 to fit various nonlinear models. Difference in fit of the models was compared using null-model likelihood ratio and Akaike's information criteria. Based on these parameters, shoot emergence time was best fit with a parabolic model whereas cumulative percentage of emergence, vegetative growth and plant biomass were best fit with a logistic model. If timing of emergence increased with planting depth, this factor had very limited effect on Carolina redroot emergence and vegetative growth. The required planting depth for reducing emergence by 50% was between 15 and 16 cm, far beyond the 3 cm of sand applied for improving rooting of cranberry stolons. Decreased soil water content affected plant height and rate of shoot emergence with 26% and 23% soil water content, respectively, for reaching a 50% reduction of these two parameters. Reduction of rhizome water content was the most effective factor for reducing Carolina redroot emergence, plant height, and shoot biomass with required rhizome water content for reaching a 50% reduction of these parameters ranging from 53% to 57%. If rhizome submersion duration had little effect on plant height, it had a more drastic on shoot emergence and belowground biomass with 50% shoot emergence and root biomass reduction occurring when rhizomes were flooded for 143 days and 127 days, respectively. Darkness did not influence shoot emergence but significantly reduced root and shoot biomass by 75% and 53%, respectively, compared to the light conditions, and completely inhibited the development of new rhizomes.

THE LONG-TERM EFFECTS OF COVER CROPS AND FUMIGANTS ON WEED POPULATIONS IN FLORIDA. N. Boyd*[1], S. M. Sharpe[2], J. Yu[1]; [1]University of Florida, Balm, FL, [2]University of Florida, Wimauma, FL (435)

ABSTRACT

Pest management is a critical issue for tomato growers in Florida. Fumigants are one of the primary tools used for the management of weeds and soil-borne pathogens. A four year trial was conducted in two fields at the Gulf Coast Research and Education Center to evaluate the effects of fumigants and fallow management on weed densities over time. The experimental design was a split-plot design with four blocks with fumigant as the main plot and fallow treatment as the sub-plot. Fumigant treatments included a nontreated control, 396 kg ha^{-1} Paladin Pic-21, 308 kg ha^{-1} Pic-Clor 60, and 396 kg ha^{-1} Paladin + 475 kg ha^{-1} K-Pam. Fallow treatments were a sorghum-sudangrass cover crop versus chemical fallow. Though not always significant, nutsedge density tended to be lower where Paladin + K-Pam were applied compared with all other fumigants and the nontreated control. Purple nutsedge densities were higher at tomato transplant where cover crops were planted during the fallow period versus chemical fallow. Fallow treatments and fumigants did not have a consistent effect on broadleaf and grass weeds in planting holes.

PYROXASULFONE FOR WEED CONTROL IN CHICKPEA, LENTIL, AND FAVA BEAN. H. Hatterman-Valenti*[1], B. Johnson[2]; [1]North Dakota State University, Fargo, ND, [2]North Dakota State University, FARGO, ND (436)

ABSTRACT

Grain legumes are important components of cereal-dominated cropping systems in North Dakota due to their ability to fix atmospheric nitrogen, break graminaceous crop disease cycles, and improve soil quality. Unfortunately, the weed control options are rather limited. Over the past three years pyroxasulfone has been evaluated alone as a preemergence or early postemergence following a preemergence application of metolachlor and sulfentrazone or metolachlor and metribuzin for weed control and crop safety using chickpea, lentil, and faba bean. In general, control of common lambsquarters, redroot pigweed, and green foxtail increased with increasing rate of pyroxasulfone applied preemergence, but rarely provided satisfactory control (≥ 85%) even early in the growing season. The early postemergence application of pyroxasulfone generally improved weed control ratings compared to the metolachlor and sulfentrazone or metolachlor and metribuzin alone applications, especially later in the growing season, but the numerical differences were not statistically different. Little to no crop injury was observed with any of the treatments. Yield results suggested that the addition of pyroxasulfone postemergence resulted in the greatest yields regardless of the grain legume, but again numerical differences often were not statistically different to the yields from the preemergence combination treatment. Overall results suggest that pyroxasulfone could provide growers another weed management tool when producing chickpea, lentil, or faba bean.

SWEETPOTATO TOLERANCE TO OFF-TARGET MOVEMENT OF DICAMBA. M. W. Shankle*, S. L. Meyers; Mississippi State University, Pontotoc, MS (437)

ABSTRACT

Field research was conducted at the Pontotoc Ridge-Flatwoods Experiment Station in Pontotoc, Mississippi to determine the effects of simulated off-target movement of dicamba on sweetpotato in 2018. The trial was a randomized complete block (RCB) with 5 replications. Plots were 3.33 X 30 ft. having one 40-inch row with a guard row separating treatments. The trial area was prepared by conventional tillage. A preplant incorporated insecticide application of Lorsban at 2 qt/ac and Bifenthrin at 19 oz/ac was applied immediately prior to bedding. After bedding, rows were rolled and Valor SX at 2 oz/ac was applied prior to transplanting. Beauregard B-14 sweetpotato slips were transplanted on June 11, 2018. Command at 43 oz/ac was applied on June 12, 2018 for weed control. Dicamba treatments were applied post-transplant (POST) at 1, 3, 5, and 7 weeks after transplant (WAT). Treatments include XtendiMax® POST at 2.75 oz/ac (1/8X), 1.375 oz/ac (1/16X), 0.34 oz/ac (1/64X), 0.043 oz/ac (1/512X).

Ratings for crop tolerance (injury) were made at 1, 2, 3, and 4 weeks after treatment (WAT) for each treatment. Sweetpotatoes were harvested on October 30, 2018 at 141 days after transplant (DAT). Sweetpotatoes were graded to determine US No.1, Canner, Cull, and Jumbo yield grades. Total marketable yield was recorded as the sum of US No.1, Canners, and Jumbo grade yields. Analysis of variance was conducted using Fisher's protected LSD (α=0.05).

Sweetpotato plant injury with dicamba applied at 1 WAP was 6% or less at 1 WAT. At 2 WAT, injury with 1/8x rate was greater than injury at 1/64X and 1/512X, and at 3 and 7 WAT, injury increased with higher rates up to more than 25% with the 1/8x rate. Plant injury with treatments applied at 3 WAP ranged from 12 to 20% at 1 WAT. At 2, 3, and 4 WAT, injury was less with 1/512x rate compared to at least 25% with higher rates. Plant injury with treatments applied at 5 WAP was less than 5% for the first 2 WAT due to plant stress induced by hot, dry environmental conditions. After a rainfall event, there was no injury with the 1/512x rate, but at least 39% for 1/64, 1/16, and 1/8x rates at 3 WAT. Injury with dicamba applied at 7 WAP increased with an increase in rate. Injury with 1/512x and 1/64x rates ranged from 17 to 2% and 31 to 6% over the 1 to 4 WAT evaluation period, respectively. However, injury with higher rates of 1/16x and 1/8x ranged from 65 to 76% and 68 to 83% over the same 1 to 4 WAT timeframe, respectively. Sweetpotato storage root yield was not different with simulated off-target dicamba rates compared to the untreated check. Yield across all rates of dicamba applied at different stages of plant development was not different compared to the untreated check, except the 1 WAP time. Total marketable yield with dicamba applied at 1 WAP was greater than all treatments including the untreated check. Future research is necessary to further examine the cause of this relationship.

EPA'S REGISTRATION REVIEW PROCESS AND ITS POTENTIAL IMPACT ON HERBICIDE USE. C. Moore*; Syngenta Crop Protection, LLC, Greensboro, NC (438)

ABSTRACT

AN UPDATE OF THE NEW EPA MANDATED REQUIREMENTS FOR PARAQUAT CONTAINING PRODUCTS: WHAT DOES THIS MEAN FOR THE END-USER AND REGISTRANT. M. U. Dixon*; Syngenta, Greensboro, NC (439)

ABSTRACT

Paraquat products are valuable components in integrated weed management programs associated with conventional and genetically modified crops. Furthermore, paraquat is extremely important where glyphosate resistance in weeds has been identified and is also an essential component in delaying the development of resistance to glufosinate in crops that are designed to tolerate that herbicide. Additionally, but no less important, paraquat is a critical tool in reduced and no-till farming which leads to reduced soil erosion and a significantly reduced carbon footprint when compared to conventional cultivation. On December 14, 2016, the United States Environmental Protection Agency issued the Paraquat Dichloride Human Health Mitigation Decision that specified required changes for who and how paraquat containing products may be used. These changes include label changes, creation and distributions of supplemental warning materials, new training requirements for paraquat users, requirement for closed system packaging and restrictions on who may use paraquat products. These changes will be implemented in a three phase process with the final requirements having to be in place by October 1, 2020. The first phase has been completed however there have been changes in the timelines for phase 2 and phase 3 to allow adequate time for label review and implementation.

ANTARES PRIME AND ANTARES PRO: NEW PRODUCTS FOR THE AGRONOMIC CROP AND T&O MARKETS. M. C. Cox*, M. Wayland; Helena Agri-Enterprises, Memphis, TN (440)

ABSTRACT

ANTARES® PRIME and ANTARES® PRO: New Products for the Agronomic Crop and

T&O Markets

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Herbicide resistance across multiple modes-of-action in soybean systems warrants improvement in new product formulations, specifically addressing the need for two or more herbicide modes-of-action per application. Similarly, resistance or increased herbicide tolerance issues have also been noted in the turf and ornamental market, along with incompatibilities within specific tank mixtures. ANTARES® PRIME is the only commercially-available, liquid pre-mixture of sulfentrazone and cloransulam-methyl and is formulated by Helena Agri-Enterprises, LLC. with a proprietary, co-adjuvant system designed to maximize spray mixture efficacy and field performance. Field studies conducted across seven states in the U.S. from 2016 to 2017 evaluated preemergence control of various weeds with ANTARES® PRIME at 0.27-0.47 L ha^{-1}. Residual control of several weeds including tall waterhemp (*Amaranthus rudis*), ivyleaf morningglory (*Ipomoea hederacea*), and giant foxtail (*Setaria faberi*) were often higher at 35 or 42 DAT with ANTARES® PRIME than comparison herbicide premixes containing sulfentrazone + cloransulam-methyl, sulfentrazone + s-metolachlor, or s-metolachlor + metribuzin. These results corroborate previous research indicating specific problematic weeds targeted by sulfentrazone applications in soybean.

ANTARES® PRO is a unique, liquid sulfentrazone formulation registered for use in specialty markets, including turf and ornamental. Although similar to other sulfentrazone formulations in these markets, field and laboratory evaluations from 2015-2018 suggest ANTARES® PRO often provides enhanced weed control and improved tank-mixing compatibility with common grassy weed herbicides when compared to current sulfentrazone standards at equivalent rates.

ETHOXYLATED FATTY ACID METHYL ESTERS (EFAME™): A NEW CLASS OF SURFACTANTS FOR AGRICULTURE. K. Crosby*[1], T. Anderson[2]; [1]Adjuvants Unlimited, LLC, Memphis, TN, [2], Liberty Township, OH (441)

ABSTRACT

Ethoxylated fatty acid methyl esters (EFAME™) are a new class of surfactants for agriculture. An exemption from tolerance was granted by the USEPA in June 2018, allowing for use as an inert ingredient in pesticide formulations and adjuvants. Made from 40% sustainable raw materials, this class has several useful properties for use as non-ionic surfactants in herbicide formulations including wetting comparable to alcohol ethoxylates, low propensity to form gel phases, low mammalian and aquatic toxicity, very low VOC and excellent biodegradability. Additionally, surprising solvent characteristics for some active ingredients have been discovered. Thus EFAME™ can serve as the basis for environmentally safer pesticide formulations and adjuvants. Field trial results with several herbicides will be discussed.

DROPLET SIZE IMPACT ON ACIFLUORFEN AND LACTOFEN EFFICACY FOR PALMER AMARANTH (*AMARANTHUS PALMERI*) CONTROL. L. X. Franca*[1], D. Dodds[1], G. Kruger[2], T. R. Butts[2], J. P. McNeal[3], S. Davis[4], J. J. Williams[4], B. Norris[4]; [1]Mississippi State University, Mississippi State, MS, [2]University of Nebraska-Lincoln, North Platte, NE, [3]Mississippi State University, Mississippi State, Mississippi, MS, [4]Mississippi State University, Starkville, MS (442)

ABSTRACT

Widespread occurrence of glyphosate and ALS-resistant Palmer amaranth has led to increased use of protoporthyrinogen oxidase (PPO) inhibiting herbicides. Lactofen and acifluorfen are non-systemic, PPO-inhibiting herbicides used to control several annual broadleaf species in soybeans, cotton, and peanuts. Concerns exist with regard to the dissemination of Palmer amaranth populations resistant to PPO-inhibiting herbicides across the Midwestern and Southern United States. Palmer amaranth populations resistant to PPO-inhibiting herbicides have been reported in Arkansas, Tennessee, Illinois, and Mississippi. Therefore, efficacious and cost effective means of application are needed to maximize lactofen and acifluorfen effectiveness.

Experiments were conducted in 2016, 2017, and 2018 across three locations in Mississippi and Nebraska to evaluate the influence of droplet size on lactofen and acifluorfen effectiveness for Palmer amaranth control. Lactofen (Cobra®, Valent U.S.A. Walnut Creek, CA) at 0.21 kg ai ha^{-1} and acifluorfen (Ultra Blazer®, United Phosphorus Inc., King of Prussia, PA) at 0.42 kg ai ha^{-1} were applied with crop oil concentrate (Agri-Dex®, Helena Chemical Company, Collierville, TN) at 1% v/v using the following droplet sizes: 150, 300, 450, 600, 750, and 900 μm. Prior to experiment initiation, the droplet size spectra for each herbicide was characterized in a low speed wind tunnel at the Pesticide Application Technology Laboratory at University of Nebraska, North Platte, NE. Treatments were POST applied to 15 cm Palmer amaranth using a tractor mounted sprayer equipped with a CAPSTAN® AG Pulse Modulated Sprayer (Capstan Ag Systems, Inc., Topeka, KS) equipped with Wilger Precision Spray Technology Tips (Wilger Inc., Lexington, TN) operated at 4.8 km per hour using a spray volume of 140 L ha^{-1}. Visual Palmer amaranth control was evaluated at 7, 14, 21, and 28 days after application. Fifteen plants per plot were tagged prior initiation of the experiment and used for dry biomass determination at the end of the experiment. Data were subjected to analysis of variance using PROC MIXED procedure in SAS® v. 9.4 (SAS Institute Inc., Cary, NC) and means were separated using Fischer's Protected LSD at α=0.05. In addition, a generalized additive modelling (GAM) analysis was conducted for optimal droplet size determination to maximize herbicide efficacy and mitigate spray drift.

Palmer amaranth control did not differ with respect to droplet size using lactofen, regardless of rating period. Acifluorfen applied using 300 µm droplets resulted in the greatest Palmer amaranth control, regardless of rating period. Lactofen applied at all droplet sizes resulted in significant dry biomass reduction. Acifluorfen GAM models suggest that the greatest Palmer amaranth control could be achieved with 250 µm droplets. Additionally, droplets ranging from 180 to 310 µm could be used to maintain 90% level of maximum weed control.

DEEP LEARNING FOR CROP AND WEED DETECTION. W. L. Patzoldt*; Blue River Technology, Sunnyvale, CA (443)

ABSTRACT

Deep Learning for Crop and Weed Detection

William L. Patzoldt*; Blue River Technology, Sunnyvale, CA (443).

Abstract. Deep learning is an emerging subfield of artificial intelligence that allows computers to teach themselves how to solve problems. Deep learning has especially been useful in the identification of objects from pictures, whether the objects are people, cars, or plants. Research has demonstrated that deep learning technology can identify plants from images, and further separate plants into pre-determined categories (e.g., crops or weeds). The process of teaching computers to identify and differentiate plants is similar to teaching humans, which involves creating test sets of plants with correct labels for the purpose of training. Students (or computers) learn how to associate combinations of specific plant features with the correct answer. Once humans and computers have identified and learned how to associate feature combinations with specific plants, it becomes easier to remember how to identify the plants in future settings. Once trained, a human or computer can remember, or recall, correct plant identification almost instantaneously. In agriculture, the ability to identify and differentiate plants creates the opportunity for management at the plant level. Specifically, the identification of crops and weeds allows the application of herbicides to weeds and not crops, which is the current emphasis of See & Spray™ technology. The application of herbicides to only weeds has the potential to reduce herbicide input costs, facilitate more aggressive adjuvant combinations, or allow for cost effective resistance management programs containing multiple site-of-action chemistries. Beyond herbicides, the ability to target crops opens the door for more efficient applications of fungicides, insecticides, biologicals, or plant nutrients.

REDESIGNING HSMSO ADJUVANTS: NOVEL TERPENE POLYMER CONTAINING FORMULATION. P. M. McMullan*[1], M. Fiery[2]; [1]Ramulus LLC, Grimes, IA, [2]Miller Chemical & Fertilizer, LLC, Hanover, PA (444)

ABSTRACT

The majority of postemergence herbicide applications in corn, cotton, and soybeans consist of glyphosate tank mixed with an additional herbicide, which can be either hydrophilic or lipophilic in nature. The majority of these tank mix partners require or recommend some type of oil-based adjuvant be included in the spray mix. It is imperative that the oil-based adjuvant not negatively affect glyphosate efficacy. As defined by ASTM, high surfactant modified vegetable oil concentrates contain between 25 to 50% surfactant and a minimum of 50% modified vegetable oil (methylated seed oil is a type of modified vegetable oil). Typical high surfactant oil concentrates (HSOCs) contain 60% oil and the remainder being emulsifier with a minimum of 25% overall surfactant content in the formulation. However, the ASTM definition allows for the incorporation of unique materials in the formulation. However, it is imperative that the unique formulations enhance pesticide performance. Pinolene® is a terpene polymer that increases deposition and the time for pesticide uptake that acts through extending the partition coefficient period with the leaf cuticle. Pinolene keeps the pesticide on the leaf surface in a liquid matrix, preventing drying out of the pesticide deposit while preventing washoff of pesticides. Three unique high surfactant oil concentrate adjuvants comprised of surfactant, methylated seed oil, and Pinolene were formulated and evaluated for enhancement of hydrophilic and lipophilic herbicide efficacy in the greenhouse. One formulation was selected based on its overall ability for herbicide efficacy enhancement and branded as Hybrid™. Numerous field efficacy trials have been conducted between 2015 and 2017 comparing Hybrid to other commercial HSMSO adjuvants for enhancement of both hydrophilic and lipophilic herbicide efficacy. Research results have shown that Hybrid consistently gave the highest efficacy over a number of weed species and number of herbicide chemistries. Hybrid is a novel HSMSO adjuvant with a unique combination of methylated seed oil and Pinolene technology. This unique combination provides for improved weed control and decreased crop injury compared to other HSMSO adjuvants.

PARAQUAT: AN EXAMINATION FOR DISCOVERY. R. K. Zollinger*[1], P. J. Porpiglia[2]; [1]AMVAC, Spokane Valley, WA, [2]AMVAC, Putnam Valley, NY (445)

ABSTRACT

Replicated field research was conducted in 2018 to evaluate burndown weed control from paraquat applied alone and with other herbicides. Academic researchers conducted 13 field trials in ND, NE, IL, MO, IN, OH, MI, SC, AR, LA, TN, and TX. Paraquat was applied alone with surfactant and with 2,4-D, dicamba, and atrazine herbicides with petroleum oil concentrate adjuvant. Efficacy evaluations were taken at 7 and 21 days after application. 32 weed species were evaluated which consisted of 6 grass, 13 broadleaf winter annual, and 13 broadleaf summer annual weed species. Generally, weed control from paraquat applied with tank-mix herbicides was excellent. 35 of 56 species showed near complete control from all chemical treatments. 14 of 56 species showed 91-99% control from tank-mix treatments with paraquat. 7 of 56 species showed variable control (17-99%) from all chemical treatments. Treatments applied after 2 pm were more phytotoxic than those applied prior to noon. Treatments applied to weeds 3 to 6 inched tall resulted in near complete control. Treatments applied to weeds greater than 6 inches resulted in surviving weeds. These weed species include grass, morningglory, Palmer amaranth, horseweed, henbit, and lambsquarters. 2,4-D provided the least enhancement of weed control with paraquat. Atrazine provided the greatest enhancement of weed control with paraquat. Horseweed control required 2,4-D or dicamba as a tankmix partner with paraquat. Henbit control required application of atrazine + 2,4-D or dicamba with paraquat to plants less than 6 inches tall. Wild buckwheat is tolerant to 2,4-D and does not improve control when applied with paraquat. Lambsquarters retains spray droplets less than most other broadleaf species. Addition of an effective surfactant improves droplet retention and herbicide activity. For effective weed control, paraquat should be applied to weeds 3-6 inches tall, applied with atrazine, applied in the afternoon with lower light conditions, and applied with good adjuvants that increase droplet retention.

NEW FINDINGS ON ULTRA-COARSE SPRAYS AND TEST METHODS. D. C. Bissell*[1], S. Fredricks[2], B. Olson[2], C. Hogan[2], G. K. Dahl[1], L. C. Magidow[3], J. Gednalske[4]; [1]Winfield United, River Falls, WI, [2]University of Minnesota, Minneapolis, MN, [3]Winfield United, Maplewood, MN, [4], River Falls, WI (446)

ABSTRACT

Spray based application of crop protectants requires accurate measurement of the drop size distribution of the spray used in order to correctly predict the deposition location of the spray, and to determine guidelines for spraying to minimize off target deposition. Measurements of such spray drop distributions are typically performed in low speed wind tunnels using Laser Diffraction (LD) measurements to obtain the volume distribution of the spray. Herein a second drop sizing method, Phase Doppler

Particle Analysis (PDPA) was employed and the results compared to LD measurements of 2 ultra-course sprays and 1 medium spray. The spray drop size distributions were evaluated the basis of their volume distribution, which is a description of what size droplets the liquid volume of the spray is partitioned into and is biased towards large droplets as volume is proportional to diameter cubed. They were hence also evaluated based on their number distribution, which is the total count of droplets of each size and gives a more accurate representation of how the spray is transported from the nozzle to deposition location. It was found that the LD measurements typically exhibited a truncated number distribution measurement, with no drops appreciably smaller than the peak diameter measured, and the PDPA measurements revealed drops with an expected log normal distribution. Additionally the PDPA measurements typically had peak values smaller than the LD measurements on the basis of number distribution, but peak values larger than the LD measurements on the basis of volume distribution, possibly skewed by measurement artifacts at large sizes. This work shows that caution needs to be exercised when interpreting spray drop size distribution measurements and we suggest that both the number and volume distributions should be considered in assessing the potential of a nozzle and tank mixture combination for spray drift and overspray.

PERMEATE: A NEW NPE FREE, NON-IONIC SURFACTANT FROM WINFIELD UNITED. R. J. Edwards*[1], G. K. Dahl[2], J. A. Gillilan[3], T. Hayden[4], E. P. Spandl[5], J. Gednalske[6]; [1]WinField United, River Falls, WI, [2]Winfield United, River Falls, WI, [3]WinField United, Nashville, TN, [4]WinField United, Owensboro, KY, [5]Winfield United, Arden Hills, MN, [6], River Falls, WI (447)

ABSTRACT

Introducing Permeate™ (NPE free surfactant-based adjuvant) from Winfield® United. Permeate™ adjuvant is a next generation non-ionic surfactant that will help optimize application coverage. Permeate™ has been shown maximizes pesticide performance by improving droplet spreading through decreased contact angles with minimal expected crop injury. Permeate™ also provides patented UV protection, which protects herbicides, insecticides and fungicides from photo degradation. Permeate™ can be applied whenever a pesticide label allows for the addition of a non-ionic surfactant.

IMPROVING HERBICIDE EFFECTIVENESS AND MINIMIZING IMPACTS WITH RESEARCH, ANALYSIS, VISUALIZATION AND DEMONSTRATION. G. K. Dahl*[1], R. J. Edwards[2], E. P. Spandl[3], A. D. Makepeace[3], J. J. Skelton[4], L. C. Magidow[5], D. C. Bissell[1]; [1]Winfield United, River Falls, WI, [2]WinField United, River Falls, WI, [3]Winfield United, Arden Hills, MN, [4]WinField United, Saint Paul, MN, [5]Winfield United, Maplewood, MN (448)

ABSTRACT

Winfield® United, a Land O' Lakes company and its Legacy companies have worked for a long time to improve the effectiveness of herbicide applications and minimize off-target issues. Several herbicides, adjuvant products and application methods have been developed and brought to market. Field testing has been a strong part of the research program to evaluate product performance. Winfield United recently opened an Innovation Center in River Falls, Wisconsin. The Innovation Center greatly increased the ability of Winfield United to build and test new herbicide and adjuvant formulations. Spray droplet analysis is conducted in an industry leading wind tunnel and testing facility. Potential spray mixtures are evaluated for the risk of loss due to particle drift. Greenhouse facilities and growth chambers grow plants for testing, and help evaluate the influence of environmental conditions. Winfield United also has a new spray booth. This spray booth can be used to apply spray mixtures with multiple nozzles at field speeds up to 18 miles per hour. Spray collection methods can be used and different imaging technology can be used to observe droplets behavior and interaction with leaves. Other instruments and methods that determine how droplets behave on different waxy or hairy leaf surfaces. Winfield United is involved in Precision Agricultural Technology, GPS mapping and forecasting tools to improve decision making and weed control results. "SUSTAIN™ is a new program which is used to improve sustainability and reduce the impact of agriculture and its practices on the environment.

EFFECTS OF SELECTED ADJUVANTS OVER TWO SEASONS ON WEED CONTROL IN CORN AND SOYBEANS WITH GLUFOSINATE-AMMONIUM. J. T. Daniel*[1], T. Hoverstad[2], M. D. Owen[3], P. Johnson[4], P. Westra[5], E. Westra[5]; [1]Jim T Daniel, Keenesburg, CO, [2]University of Minnesota Southern Research and Outlet Center, Waseca, MN, [3]Iowa State University, Ames, IA, [4]South Dakota State University, Brookings, SD, [5]Colorado State University, Fort Collins, CO (449)

ABSTRACT

NOZZLE TYPE AND TIMING OF APPLICATION EFFECTS ON WEED CONTROL IN MISSISSIPPI COTTON. C. Ferguson*[1], P. H. Urach Ferreira[1], M. T. Wesley[2], L. H. Merritt[2], Z. R. Treadway[1], K. L. Broster[1], N. Fleitz[3]; [1]Mississippi State University, Mississippi State, MS, [2]Mississippi State University, MS State, MS, [3]Pentair-Hypro, New Brighton, MN (450)

ABSTRACT

A field study was conducted at the Blackbelt Research Station in Brooksville, MS to understand the effect of nozzle type and herbicide application timing on weed control in cotton. The study also compared applications made with an eight nozzle tractor sprayer compared to a four nozzle backpack sprayer. For the tractor study, five nozzle types: Ultra-Low Drift (ULD) 12004, Guardian Air (GA) 11004, Guardian Air Twin (GAT) 11004, 3D 10004, and High Flow (HF) 14008 were compared. For the backpack study, four nozzle types: Ultra-Low Drift (ULD) 12002, Guardian Air (GA) 11002, Guardian Air Twin (GAT) 11002, 3D 10002 were assessed. Applications were made at 140 L ha^{-1} (15 gal ac^{-1}). Spray pressure for the 04 nozzles was 276 kPa (40 psi) and 138 kPa (20 psi) for the HF 08 nozzle. Herbicide applications were made at four different timings: preemergence (PRE), early post (EPost), early-mid post (EMpost), and late post (LPost) corresponding to the preemergent, 2-3 leaf, 5-6 leaf, and match head square stages respectively. Programs selected were: PRE fb EPost fb LPost; EM Post only; EPost fb LPost. Treatments included a standard herbicide treatment applied at each growth stage, with the nozzle type as the variable by each timing. Results showed no difference between sprayer type or nozzle type for weed control, where all programs resulted in control at or above 90%. For yield results, neither nozzle type nor sprayer type was significant so data were pooled across those factors. Yield results showed that the EMpost program resulted in the best yield (2600 lbs seed cotton / acre) compared to the other two programs respectively (2312 and 2340 lbs seed cotton / acre). The results are less indicative of pursuing a one-time application only, but rather reflects a need to further examine glufosinate tolerance among cotton varieties. Given that weed control results were all optimal, the difference in yield appears to be more a factor of cotton sensitivity to a late season glufosinate application than due to yield loss from weed control. The study is to be replicated in 2019, which should provide greater information to better understand results from the 2018 data.

EMERGENCE OF MULTIPLE RESISTANCE IN *CONYZA CANADENSIS* RESISTANT TO GLYPHOSATE. C. Palma-Bautista*[1], D. A. Mora[2], R. Dominguez-Mendez[2], A. M. Rojano-Delgado[2], J. Portugal[3], R. De Prado Amian[4]; [1]University of Cordoba, CÓRDOBA, Spain, [2]University of Cordoba, Cordoba, Spain, [3]Polytechnic Institute of Beja, Beja, Portugal, [4]University of Cordoba, Córdoba, Spain (451)

ABSTRACT

The physiological and biochemical bases for multiple resistance to ALS and EPSPS inhibitor herbicides were studied in two populations of *Conyza canadensis* (RG and SG), harvested in southern Spain. Using whole plant dose-response and enzymatic activity studies, the results showed only cross resistance to the sulfonylureas group, but not to the other ALS chemical groups. Regarding glyphosate, the dose-response studies showed that the RG population was 11.8 times more resistant than the STG population, while the inhibition of EPSPS enzyme (I_{50}) revealed similar values for both populations. Moreover, the absorption and translocation were not the mechanisms responsible for resistance in horseweed for tribenuron-methyl. While in the case of glyphosate they were the main resistance mechanisms. Metabolic studies showed differences between both populations for tribenuron-methyl, being higher in the RG than the SG population; however, for glyphosate, no metabolite appeared in either populations of *C. canadensis*.

These results documented the first case of C. canadensis with multiple resistant worldwide and demonstrated that the TSR and NTSR mechanisms are involved in the resistance to sulfonylureas, while only a NTSR mechanism is involved in glyphosate resistance.

NON-TARGET IMPACTS OF HERBICIDES ON *TETRANYCHUS URTICAE* AND ITS PREDATOR, *PHYTOSEIULUS PERSIMILIS*: IMPLICATIONS FOR BIOLOGICAL CONTROL. M. A. Cutulle*, R. A. Schmidt-Jeffris; Clemson University, Charleston, SC (452)

ABSTRACT

A key element of conservation biological control is identifying and limiting use of pesticides that have substantial non-target effects on natural enemies to prevent biological control disruption. The Phytoseiidae (predatory mites) are one of the most studied natural enemy groups in the field of pesticide non-target effects. While there is substantial research on the non-target effects of insecticides on arthropod natural enemies, research on herbicide impacts is limited. Natural enemies, including phytoseiids, associate with weeds due to the presence of alternative prey, shelter, or floral resources. Therefore, a whole-systems approach to IPM should integrate weed management with biological control. We conducted a study to examine the non-target impacts of common vegetable herbicides on an important predatory mite, *Phytoseiulus persimilis*, and the primary pest that it controls, *Tetranychus urticae*. Two assays, a slide dip assay and a treated Petri dish assay were used to assess the effects of direct application and walking on residues, respectively. *S*-metolachlor was found to be highly toxic to *P. persimilis* and had minimal effect on *T. urticae*, indicating that this compound does not favor biological control. Dicamba, oxyfluorfen, and napropramide were also identified as potentially disruptive. Halosulfuron-metyl, flumioxazin, and mesotrione were found to be compatible with biological control by *P. persimilis*. We also determined that the Petri dish assay may be more useful than slide dips for future assessment of herbicide non-target effects. Future efforts should continue to examine the impacts of weed management on natural enemies to better integrate pest management practices.

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COMPARISON OF ALTERNATIVE WEED CONTROL METHODS WITH FOUR COLD HARDY WHITE WINE GRAPES. j. M. Stenger, A. Svyantek, c. M. Auwarter, H. Hatterman-Valenti*; North Dakota State University, Fargo, ND (453)

ABSTRACT

To enable production under the challenging environmental conditions of North Dakota, specialized cropping practices may be required. North Dakota offers challenges both due to harsh winter conditions as well as low precipitation. These areas may be impacted by weed control options, especially those which influence the near-vine microclimate. Alternative weed control methods were tested in an experimental vineyard near Absaraka, ND for their ability to control annual weed species as well as for their effects on vine growth and production. The experiment was planted in 2012 and arranged in a randomized complete block design with a full factorial including four cold-climate white wine cultivars ('Alpenglow', 'Brianna', 'Frontenac Gris', and 'La Crescent') and six within-row weed control methods (woven landscape fabric, herbicide (glufosinate-ammonium, 32 fl. oz/A, with flumioxazin, 6 oz/A), black polyethylene film, straw mulch, tillage, and turfgrass) with four replications. Yield was impacted by weed control measure in Alpenglow and Brianna. In Alpenglow, plants treated with either black film or landscape fabric had higher yields than those treated with herbicide. Brianna vines treated with turfgrass had statistically lower yields compared to all other methods. These differences in yield were due to differences in average cluster size and relative number of clusters produced. Custer weight was significantly lower in turfgrass treated Brianna vines relative to all other methods of weed control. Frontenac Gris vines receiving either landscape fabric or turfgrass had larger clusters when compared to those treated with either straw or herbicide. Alpenglow vines had differences in cluster weight which mimicked trends in overall yield. Fruit pH and titratable acidity did not statistically differ across treatments. Brix was only affected by weed control treatment in Brianna vines, however, such differences were year dependent indicating an increased sensitivity to environmental variations in Brianna relative to the other regional cultivars. Overall, both landscape fabric and polyethelene film were effective alternatives weed control methods in comparison with traditional herbicide use for the six-year period.

SWEETPOTATO TOLERANCE TO PENDIMETHALIN. S. L. Meyers*[1], K. M. Jennings[2], D. Miller[3], M. W. Shankle[1], J. L. Main[1], S. C. Smith[2], C. J. Morris[1], L. D. Moore[2], M. D. Waldschmidt[2]; [1]Mississippi State University, Pontotoc, MS, [2]North Carolina State University, Raleigh, NC, [3]Louisiana State University AgCenter, St. Joseph, LA (454)

ABSTRACT

Field trials were conducted in Pontotoc, MS in 2017 (once) and 2018 (twice) and in St. Joseph, LA and Clinton, NC in 2018 to determine the effect of pendimethalin rate and application timing on sweetpotato crop tolerance, yield, and storage root quality. Plots consisted of two 6.0 m rows (North Carolina) or three 7.6 m (Louisiana and Mississippi in 2017) or 9.1 m rows (Mississippi in 2018). At all locations rows were 1m apart and in-row plant spacing was 30 cm. Treatments consisted of five pendimethalin rates (266; 532; 1,065; 1,597; and 2,130 g/ha) by two application timings [0/1 or 14 d after transplanting (DAP)]. The experiment design was a randomized complete block with four replications. Sweetpotato plants were visually rated 2, 4, 6, 8, 10, and 14 wk after transplanting (WAP) for crop injury on a scale 0% (no injury) to 100% (crop death). Plots were harvested 110 to 120 DAP and graded into jumbo, one, canner, and cull (misshapen roots). Canner and cull roots were combined as processing grade. The aggregate of all grades was used to calculate total yield. Sweetpotato injury data were subjected to arcsin transformation. All data were subjected

to ANOVA by Proc GLM with the fixed effects of pendimethalin application rate and timing and random effects of location and replication within location. Analysis of injury data did not include ratings from the non-treated check which were 0% with a variance of 0. Due to a lack of location by treatment interaction, data for crop injury and yield of all grades was combined across all five locations. Crop injury (primarily stunting) was minimal (≤ 4%) through 6 WAP and no injury was observed from 8 to 14 WAP. The non-treated check yielded 5,530; 17,580; 8,960; and 32,060 kg/ha of jumbo, one, processing, and total grades, respectively. Pendimethalin application timing did not influence jumbo, one, or total sweetpotato yield. However, all rates of pendimethalin resulted in reduced processing grade sweetpotato yield (7,200 to 7,830 kg/ha) compared to the non-treated check. With regards to pendimethalin application timing, applications made 0/1 and 14 DAP resulted in similar jumbo, one, and total sweetpotato yields as the non-treated check. However, applications made at 0/1 and 14 DAP did reduce processing grade sweetpotato yield (7,520 and 7,740 kg/ha, respectively) compared to the non-treated check.

CULTIVATION METHOD AND FREQUENCY TO REDUCE WEED DENSITY PRIOR TO DIRECT SEEDED BOK CHOY. P. J. Dittmar*[1], D. D. Treadwell[1], R. Randhawa[2], D. Farnsworth[1], J. Perez[1]; [1]University of Florida, Gainesville, FL, [2]Virginia Tech, Blacksburg, VA (455)

ABSTRACT

Leafy green vegetables such as bok choy have minimum herbicides registered for applications and require systems weed management. Cultivation and burndown herbicides utilized prior to planting can reduce weed density prior to planting the cash crop. The study objective was to utilize cultivation, cover crops, and glyphosate to reduce weed populations prior to planting bok choy. The entire field was cultivated and treatments were applied during the 7 wks after initiation (WAI) weeks prior to planting. The cultivation treatments were applied every week (weekly) or every other week (biweekly) and included a tine cultivator, s-tine cultivator, or rotavator. The other treatments were pearl millet (20 lb./A) mixed with iron clay pea (20 lb./A) [cover crop], glyphosate at 3 wk interval, and a nontreated. Weeds were counted weekly before cultivation or spraying and separated by species. Bok choy was planted at 8 WAI. At 2 WAI, all treatments were similar to the nontreated except s-tine weekly and rotavator weekly. The tine cultivator did not control nutsedge and dayflower that were larger than 5 inches tall so over time the number of weeds increased over the 7 WAI. At the end of 7 wk, all the s-tine and rotavator cultivation treatments were similar; cover crops had more weeds than these treatments, but fewer than the tine cultivator. After planting bok choy at 8 WAI, total weed species were not different at 10 through 14 WAI. However, nutsedge was lower in both s-tine, both rotavator, and the glyphosate programs compared to the nontreated and tine biweekly. The lack of total weed density is because the treatments were applied when summer annual weeds were predominate and the bok choy was growing during the cool season. Bok choy yield was not different among treatments, but cover crop, glyphosate, rotavator weekly, and rotavator biweekly had 23% to 46% more yield than the nontreated. A partial budget analysis shows a profitability index of $27.81 to 43.38 compared to the nontreated for all treatments except tine biweekly. Although many of the cultivations provided the greatest profitability index, but they have the greatest impact on the soil structure. Glyphosate provide excellent control of perennial weeds, cultivation prior to planting bok choy and during the cash crop can lower this possibility. The success of cultivation, cover crops, and glyphosate is dependent on the predominate species in the field and the time of year the bok choy will be planted.

SELECTING FOR BUNCH TYPE SWEETPOTATO LINES: A WEED SCIENCE PERSPECTIVE. M. A. Cutulle*[1], H. T. Campbell[1], P. Wadl[2]; [1]Clemson University, Charleston, SC, [2]USDA-ARS, Charleston, SC (456)

ABSTRACT

Tolerance to weed interference is a desirable trait to select for in a sweetpotato breeding program. Most commercial cultivars exhibit a creeping-type growth habit. Cultivars exhibiting a vine-type growth habit are typically susceptible to weed interference. Comparatively, sweetpotato plants that exhibit a bunch-type growth habit are more competitive against weeds. However, there is only one commercially available sweetpotato variety. At the United State Vegetable laboratory in Charleston six sweet potato clones that exhibited a bunch-type growth habit were selected for placement in weed interference studies. In the 2018 trial 3 commercial cultivars and 6 experimental selections were kept weed free at intervals of 0, 2, 3 and 4 weeks. Weed counts, insect damage, and yield data were collected from the trial.

WEED CONTROL IN ORGANIC BLUEBERRIES: COMPARING THERMAL, MECHANICAL, AND CHEMICAL TOOLS. E. N. Augerson, M. L. Moretti*; Oregon State University, Corvallis, OR (457)

ABSTRACT

Organic blueberry production accounts for approximately 25% of the crop acreage in the Pacific Northwest. In organic production, weed control is often listed by growers as the most onerous and time-consuming activity. Many growers still rely on hand-weeding, but labor shortage and higher costs are making this practice less viable. New weed control options compatible with organic production are needed. The objectives of this research were to evaluate commercially available saturated steam, brush weeder, and two organic herbicides (caprylic acid plus capric acid, and ammonium nonanoate). A commercial blueberry field in transition to organic certification was used for this experiment. The experimental design was a split-plot with the treatments above as main plots plus an untreated control and additional weed control treatments (untreated, steam, brush weeder, caprylic acid, and ammonium nonanoate) four weeks after the main plot treatment as subplots. The Treatments applied to the base of blueberry plant row (30% of the field). The steam and the brush weeder provided 80 to 95% weed control. The organic herbicides efficacy ranged from 50 to 80% weed control. The brush weeder and the steam were 3- to 6.5-fold more cost-effective than organic herbicides. The data presented is the first year of a three year project.

ASPARAGUS WEED CONTROL PAST, PRESENT, AND FUTURE. B. H. Zandstra*[1], C. J. Phillippo[2]; [1]Michigan State University, East Lansing, MI, [2]N/A, East Lansing, MI (458)

ABSTRACT

Asparagus weed control past, present, and future. BH Zandstra, Michigan State University, East Lansing, MI.

ABSTRACT

Asparagus is a perennial crop which has a productive life of 12-15 years. The crop is grown without tillage for the duration of the crop life.

An asparagus weed control trial was conducted over the past 6 years at Hart, MI on a Spinks loamy sand soil to determine whether repeated use

In another experiment applied in Fall 2017 on Spinks loamy sand, indaziflam at 0.05, 0.07, or 0.1 kg/ha provided good control of Powell amarar

In another experiment on Marlette fine sandy loam, asparagus treated with indaziflam in fall 2017, early April 2018, or late April 2018 had nc

Flumioxazin caused a significant increase in asparagus cull spears, but no reduction in total yield. Clomazone plots had reduced yield, probak

AN IR-4 COLLABORATION SUCCESS STORY: EDAMAME. M. M. Williams*[1], M. Arsenovic[2], W. Barney[2], D. Kunkel[2]; [1]USDA-Agricultural Research Service, Urbana, IL, [2]Rutgers University, Princeton, NJ (459)

ABSTRACT

Edamame (*Glycine max*) is the vegetable version of grain-type soybean; however, registering pesticides on these two crops involve different tracks. Prior to 2010, a generic version of clethodim was the only herbicide with a federal label for use on edamame. Due to vegetable industry interest in growing the crop domestically, a collaborative effort was undertaken to increase the number of pest management products available for edamame. Several individuals from IR-4, EPA, some universities, and USDA-ARS worked with pesticide manufacturers to facilitate the registration of specific products on edamame. Many of these approvals were made possible by translating residue data from succulent beans, without the need to generate new residue data. Regarding crop safety, field research has demonstrated that a diverse collection of edamame cultivars have a level of tolerance to several herbicides that is comparable to grain-type soybean. Such data has facilitated herbicide registration by quantifying the low risk of crop injury to these products. As of this writing, 10 herbicides from eight modes of action now have a federal label. An additional herbicide is expected to have a federal label for the 2019 growing season. In 2010, handweeding costs in edamame were approaching $1,200 ha^{-1}; however, herbicides now available greatly reduce, in some cases eliminate, the need for handweeding. Overall, this collaboration has facilitated the development of a competitive U.S. edamame industry.

ROBOTIC WEEDERS: AN EASIER PATH TO NEW WEED CONTROL TECHNOLOGY FOR VEGETABLE CROPS. S. A. Fennimore*; University of California, Davis, Salinas, CA (460)

ABSTRACT

Developing new herbicides for specialty crops has always been a challenge. Herbicides for these crops are not a priority for the agrochemical industry, and many specialty crops do not have access to effective herbicides. High-value fruit and vegetable crops represent small markets and high potential liability in case of herbicide-induced crop damage. Meanwhile, conventional and organic specialty crop producers are experiencing labor shortages and higher manual weeding costs. Hand weeding may be unavailable to specialty crop producers in the not too distant future. Robotic weeders are promising new weed control tools for specialty crops, because they are cheaper to develop and with fewer environmental and human health risks, are less regulated than herbicides. Now is the time for greater investment in robotic weeders as new herbicides are expensive to develop and few in number, organic crops need better weed control technology and governments are demanding reduced use of pesticides. Public funding of fundamental research on robotic weeder technology can help improve weed and crop recognition, weed control actuators, and expansion of weed science curricula to train students in this technology. Robotic weeders can expand the array of tools available to specialty crop growers. However, the development of robotic weeders will require a broader recognition that these tools are a viable path to create new weed control tools for specialty crops so that they get the attention and resources they deserve.

CROP RESPONSE AND WEED CONTROL FROM CARFENTRAZONE APPLIED TO STEVIA (*STEVIA REBAUDIANA*) ROW MIDDLES. J. A. Cheek*[1], R. B. Batts[2]; [1]NCSU IR-4 Field Research Center, Raleigh, NC, [2]NCSU IR-4 Field Research Center, Fremont, NC (461)

ABSTRACT

As of the 2018 growing season, there are no herbicides labeled for post-transplant use in Stevia (*Stevia rebaudiana)*, other than clethodim, a postemergence graminicide. Carfentrazone is a contact herbicide that is labeled for use for shielded row middle applications in a variety of vegetable crops, with a maximum of 6.1oz/ac per season. It controls or suppresses a wide spectrum of broadleaf weeds in these crops. Evaluations were conducted to observe crop safety and weed control from various timings and rates of Aim EC (2 lb carfentrazone-ethyl per gallon) applied under a hood to stevia row middles. Aim treatments consisted of 2 oz/ac applied at 2, 4, and 6 weeks after transplanting (WATR), 3 oz/ac applied at 3 and 6 WATR, and 2 oz/ac applied at 2 WATR followed by 4 oz/ac at 6 WATR. Weed control from 2+2+2 oz/ac had statistically similar weed control compared to weed-free checks for the majority of weeds, at the majority of the evaluation timings. Aim applied at 2+4 oz/ac provided significantly lower weed control compared to weed free checks at the later rating intervals. This was likely due to the four week interval between applications, which allowed for increased weed growth. No injury was observed from any of the treatments and yield was statistically similar between all carfentrazone treatments and the weed-free check. Carfentrazone applied post-directed in a hood can provide good row middle weed control in stevia, with great crop safety.

WEED CONTROL RESEARCH EFFORTS IN NORTH CAROLINA STEVIA (*STEVIA REBAUDIANA*). R. B. Batts*[1], J. A. Cheek[2]; [1]NCSU IR-4 Field Research Center, Fremont, NC, [2]NCSU IR-4 Field Research Center, Raleigh, NC (462)

ABSTRACT

Interest in stevia production has grown in recent years throughout the coastal Southeast. There is particular interest in North Carolina, where the existing tobacco and peanut production infrastructure could be utilized in stevia propagation, production and drying. Acreage has increased gradually over the years, but expansion of acrage has been primarily hampered by the lack of registered herbicides. Only one herbicide, clethodim, is curently labeled for use in stevia. Therefore, growers must rely heavily on hand-weeding and cultivation to manage weeds.

Herbicide trials have been and are being conducted at NC State University to identify safe and effective herbicides for stevia. The USDA IR-4 Program, based on some of this work, is presently generating residue data needed to support registration of three herbicides, s-metolachlor, halosulfuron, and ethalfluralin. Prior to labeling, each must have a maximum residue level (mrl), a.k.a a 'tolerance', established by the US EPA. Data for s-metolachlor is currently being reviewed by EPA, with the establishment of a tolerance expected in April 2019. IR-4 plans to submit the data package for halosufuron to EPA in fall 2019 and ethalfluralin data submission is planned for fall 2020.

Other trials at NCSU are focusing on several products, rates, and application timings, in an effort to identify more herbicide tools for stevia growers.

1. Winter weed control in established, dormant stevia. These trials are primarily focused on sequential applications of products to control weeds and determine if regrowth of the overwintering stevia is compromised. Products tested include linuron, paraquat, flumioxazin, indaziflam, and terbacil. In early testing, sequential applications of linuron + paraquat appear to be the most promising, along with sequential applications of terbacil.

2. Pretransplant herbicides. 2017and 2018 trials with flumioxazin, fomesafen, and sulfentrazone applied broadcast pretransplant were conducted at two locations. Flumioxazin appeared to be the safest of the these in these initial trials. Trials will be repeated in 2019

3. Herbicides applied to row middles with hoods/shields. Several trials, over several years, with carfentrazone applied to stevia row middles under a hood showed excellent crop safety. In 2018, a trial with greatly exaggerated rates also showed excellent crop safety. The registrant is currently reviewing all of ths data. Since carfentrazone is exempt for tolerance when applied in a hood/shield, the registrant can add stevia to the label without residue testing. Other herbicides will likely be evaluated when applied in this manner.

4. Post-Directed herbicides. In a 2018 trial, flumioxazin, fomesafen and sulfentrazone were applied post-directed to four week old stevia. They were compared to each other and to sequential post-directed applications of paraquat. Though weed control was quite good from all of the treatments, flumioxazin appeared to be the safest of the PPO herbicides. Three sequential applications of paraquat was also relatively safe.

5. Postemergence broadcast herbicides. Several hebicides were applied postemergence to stevia and weeds in two small trials in 2018. Results were variable, so all should be tested further, but linuron was very promising with respect to weed control and crop safety.

HANDWEEDING ORGANIC VIDALIA SWEET ONION - NECESSITY AND PRACTICALITY. W. C. Johnson III*; USDA-ARS, Tifton, GA (463)

ABSTRACT

Organic Vidalia® sweet onion is a highly profitable production system, but weed control is difficult. Previous research has consistently shown that repeated cultivation with a tine weeder provides significant weed control. Densities of cutleaf eveningprimrose (the most common and troublesome weed of organic onion production) were reduced by 59 to 92% by cultivation compared to the non-cultivated control in numerous trials from 2007 to 2015. Similarly, cultivation increased onion yields by 77% over the non-cultivated control during the same time period. Weeds escaping control will be very large at the time of harvest and undoubtedly cause losses. Given the substantial profit margin of organic Vidalia® sweet onion, it was hypothesized that a single (i.e. 'once-over') handweeding to remove weeds escaping control by cultivation would be beneficial and cost-effective. Trials were conducted from 2014 to 2017 at the Vidalia Onion and Vegetable Research Center near Lyons, GA. The experimental design was a factorial arrangement of three levels of bi-weekly cultivation with a tine weeder (2X, 4X, and non-cultivated control), two levels of herbicide treatment with d-limonene (one application and a non-treated control), and two levels of handweeding (one handweeding after cultivation and no handweeding). Data measured included weed counts, graded onion yield, and time to handweed individual plots. Cultivation 2X and 4X reduced densities of cutleaf eveningprimrose, swinecress, and henbit compared to the non-cultivated control, with no difference between cultivation 2X and 4X. Onion yields were similarly improved by cultivation. Treatment with d-limonene had no consistent effect on weed densities and graded onion yield. A single handweeding after cultivation reduced final densities of all weeds and increased onion yields. Cutleaf eveningprimrose was the predominant weed both years with densities varying from 31 plants/m2 to 139 plants/m2. When weeds were present at the lowest density (2014), cultivation followed by handweeding increased onion yields enough to justify the cost of handweeding and returns from handweeding investment averaged $2,220 and $3,040/A for cultivation 2X and 4X, respectively. When weeds were at the highest weed density (2015), returns from investing in handweeding were greater compared to conditions when weeds were sparse. In 2015 handweeding following cultivation increased onion yields enough to justify the cost of handweeding and returns from handweeding investment averaged $6,430 and $9,380/A for cultivation 2X and 4X, respectively. Based on these results, handweeding used to supplement cultivation in organic onion production is an economically viable option due to the high profit margin of the crop and yield response from improved weed control. In locations with history of intense weed pressure, the need for supplemental handweeding should be anticipated due to likelihood of numerous weed escapes. In this scenario, intense cultivation with a tine weeder supplemented by handweeding to control escapes maximizes profits in this lucrative specialty crop.

MANAGEMENT OF PARASITIC *DENDROPHTHOE* IN SEMI-TEMPERATE AND TEMPERATE FRUIT CROPS OF JAMMU-KASHMIR HIMALAYAS. A. Kumar*, R. Puniya; Sher-e-Kashmir University of Agricultural Sciences and Technology - Jammu, JAMMU & KASHMIR, (INDIA)., Jammu, India (464)

ABSTRACT

Management of parasaitic *Dendrophthoe* in semi- temperate and temperate fruit crops of Jammu-Kashmir Himalayas

Anil Kumar[1] and R. Puniya[2]

1Advanced Centre for Rainfed Agriculture, SKUAST-Jammu

2 AICRP-Weed Management, SKUAST-Jammu

Dendrophthoe is a partial stem parasite. It has leaves, flowers and fruits. Birds eat the fruits of the parasite and the seeds are excreted through droppings which fall on limbs and branches of the tree. The seed germinates under favourable conditions and gives out clusters of shoots. The seeds while sprouting produce bulged haustoria which penetrate into the bark and absorb water and minerals from the host and grow as a plant. The haustoria of the parasite serve as roots. Due to absorption of nutrients by the parasite from the host the tree gradually weakens. It poses serious losses to economically valuable fruit trees, whether growing in forests or orchards. The problem of stem parasite was found to be severe in plants like Fig, Walnut, Peach, Timbru, Apricot, Pomegranate, *Grewia* and Citrus in Udhampur district of Jammu and Kashmir, India. For management of stem parasite a field experiment was conducted during 2015 and 2016 in Udhampur district in the domain area with three treatments viz. cotton padding of 4 g copper sulphate + 0.5 g 2, 4-D sodium salt, directed spray of 0.5% paraquat on parasite and directed spray of 1% glyphosate on parasite where the parasitic weed was identified as *Dendrophthoe spp.*, family Lorenthaceae. Observations after one month of imposition of treatments revealed that directed spray of paraquat 0.5% and glyphosate 1% gave satisfactory control of *Dendrophthoe spp.* in Walnut, Timbru, Apricot, Pomegranate, Fig, Grewia and Citrus with slight phytotoxicity to host plant. However, cotton padding of copper sulphate + 2, 4-D sodium salt gave satisfactory control of *Dendrophthoe spp.* in all the host-parasite situations except for that a relatively lesser response was observed in case of Walnut, Fig and Citrus host plants.

INTRODUCTION TO SYMPOSIUM. M. Bish*; University of Missouri, Columbia, MO (465)

ABSTRACT

Recent challenges associated with off-target dicamba movement have highlighted the need for interdisciplinary collaborations to address both the current issue and the natural follow-up question "What other pesticides are moving that we cannot see?" The main objective of this symposium is to provide weed scientists a platform to

engage with experts from other disciplines regarding mechanics of weather, pesticide fates in the environment, and the importance of understanding weather tools. Dicamba research related to these topics will also be presented.

EARTH, AIR, SUN, OUTER SPACE, AND PESTICIDE DISPERSION. J. Nielsen-Gammon*; Texas A&M, College Station, TX (466)

ABSTRACT

Pesticide applications typically follow strict guidelines to optimize the effectiveness of the application while at the same time minimizing adverse health impacts and unwanted dispersion. But following the guidelines is not enough. Operators must also know the circumstances that would lead to variations in suitability within a given field and the meteorological circumstances that might cause favorable conditions to suddenly become unfavorable. The atmosphere is where the transport and dispersion takes place, and the dispersion characteristics on a given day are often determined by large-scale weather conditions. Both horizontal and vertical dispersion are strongly affected by the difference in temperature between the earth/vegetation and the overlying air: when the ground is warmer than the air, vertical dispersion is much more likely, and an increase in ground temperature through direct or indirect sunlight typically leads to increased horizontal dispersion as well. Beginning in late afternoon, the setting sun no longer can replenish the energy that the ground radiates upward to the atmosphere and to space, and the ground begins cooling. A relatively cold ground surface also leads to the development of local drainage winds and pooling of cold air, so that subtle variations in topography can have large effects on the direction of dispersal. Within this basic cycle of warming and cooling, the extent of vertical dispersion tends to follow a typical pattern that can be understood from the way turbulence forms in the atmosphere.

UNDERSTANDING WEATHER DATA: MAKING SENSE OF AN INCREASING AMOUNT OF AVAILABLE INFORMATION. D. Todey*; USDA-ARS, Ames, IA (467)

ABSTRACT

The creation of readily available monitoring equipment (temperature, humidity and wind, etc.) has greatly increased the measured data available throughout the country. Federal, state and private entities have increased the collection of data along with the provision of such data. A wide number of web sites, apps and social media provide something that "looks" like data. But is all that data good? What is actually measured data and what is synthetic? Where can this data be found? In this session we will review some issues about data and data sources, what is good information, and what to watch out for. These issues are particularly important when documenting information for drift purposes and a myriad of other potential legal issues.

SURFACE TEMPERATURE INVERSIONS AND LESSONS LEARNED IN COLLABORATING WITH WEED SCIENTISTS . P. Guinan*; University of Missouri, Columbia, MO (468)

ABSTRACT

The influence of weather and climate on weed management is evident, and the recent introduction of soybean resistant dicamba provided additional opportunities for weed, weather and climate experts to study, learn and discover together. Dr. Guinan will address the interaction between climatologists and weed scientists, and what emerged from the collaboration when it came to developing a strategy to monitor for temperature inversions. A new inversion tool and preliminary data results will also be discussed.

COMPARISON OF DICAMBA AIR CONCENTRATION FROM APPLICATIONS MADE DURING INVERSION AND NON-INVERSION CONDITIONS. S. T. Farrell*[1], R. Lerch[2], M. Bish[1], K. Bradley[1]; [1]University of Missouri, Columbia, MO, [2]USDA-ARS, Columbia, MO (469)

ABSTRACT

Few studies have been conducted to understand the extent to which ground-applied pesticides are present in the air following applications made during stable and non-stable atmospheric conditions. Air sampling studies were conducted near Columbia, Missouri, in 2017 and 2018 to determine dicamba concentrations following ground-pesticide applications. One objective of this study was to analyze concentrations of dicamba detected following on-label, daytime applications compared to off-label applications made during inversion conditions. All experiments were established within 600 meters of a weather station equipped to monitor inversions. Real-time air temperatures were utilized to guide applications. Daytime and evening applications were made within 16 hours of each other so that environmental and weather conditions over the course of the experiments were as consistent as possible. Across 10 experiments in which a labeled application of dicamba plus glyphosate was made to a 6 x 31 m area, the average concentration of dicamba detected in the first 8 hours was at least 4 times more in samples collected following the off-label, night time application compared to those of the on-label, daytime application. However, dicamba was consistently detected in both types of applications up to the end of the experiments, which concluded 72 hours following treatment. There were multiple instances in which dicamba levels decreased 8 to 16 hours after application (HAA) but then increased over the 16 to 24 HAA time period. Spearman's correlation analysis and a stepwise regression model were utilized to identify weather factors that were associated with higher dicamba concentrations. Results from these analyses indicate that air concentrations of the approved dicamba products are influenced by weather conditions associated with increased atmospheric stability.

PROCESSES CONTROLLING THE FATE OF PESTICIDES IN THE ENVIRONMENT. R. Lerch*; USDA-ARS, Columbia, MO (470)

ABSTRACT

Responsible use and management of pesticides requires a detailed understanding of the numerous processes that determine their environmental fate. This presentation will cover the major fate pathways, including soil degradation and sorption, volatilization, photolysis, and hydrologic transport, and it will provide some perspective on the key environmental compartments impacted by pesticides. Further, the critical role that plants can play in effecting pesticide fate in direct and indirect ways will be examined. For example, members of the *Poaceae* family produce allelopathic compounds (benzoxazinoids) that can directly react with *s*-triazine herbicides in soil. Plants also have a

major effect on soil quality leading to increased soil microbial activity and pesticide sorption. Although off-site transport processes typically account for <10% of applied pesticide mass, this is sufficient to cause impairment of ecosystems and human health. Thus, another focus will be the factors affecting hydrologic transport and the impact of pesticides on water quality. Water quality data will be presented demonstrating the overarching importance of soil properties on watershed vulnerability to pesticide transport. By synthesizing our knowledge of degradation and transport processes, pesticide risk assessment models can be developed to predict areas within watersheds that are most vulnerable to contamination of water and air resources. An example of a pesticide risk model will be presented as one approach to targeting conservation practices to the most vulnerable areas. Lastly, a brief overview of management practices that effectively reduce off-site transport will be reviewed, with an emphasis on the environmental trade-offs associated with these practices.

ANALYSIS OF WEATHER AND ENVIRONMENT SURROUNDING OFF-TARGET DICAMBA APPLICATIONS. M. Bish*, K. Bradley; University of Missouri, Columbia, MO (471)

ABSTRACT

Dicamba has been utilized for more than 50 years to control weeds in grain crops, such as corn. In 2017, dicamba was approved for use in dicamba-tolerant soybean and cotton. In 2017 and 2018, dicamba movement onto non-target plants was substantial. The total number of dicamba-related investigations by state departments of agriculture was 2,708 in 2017. Information on total investigations for 2018 was unavailable. In many incidences, the cause(s) of dicamba movement were attributed to factors within applicator control such as tank contamination and failure to take measures to reduce physical drift. In other incidences, the pattern of injury was inconsistent with physical drift or tank contamination. Fields that were not sprayed with dicamba had consistent dicamba-injury symptoms across the entire area or in some instances field edges remained uninjured but injury occurred further into the field. The objective of this research was to compare weather and environmental variables between successful and unsuccessful dicamba applications. Unsuccessful applications were considered as those in which dicamba did not remain on target and the cause was unexplained. Information pertaining to over 200 dicamba applications made in seven states has been used. A stepwise logistic regression model was employed to identify weather and environmental variables associated with successful dicamba applications. Soil pH, dew point temperature, wind speed, and proximity to water have been identified as factors that influenced successful applications. The influence of soil pH is being studied further in the research setting (abstract 293).

ONLINE WEED SCIENCE CLASSES AND CONTENT. B. A. Ackley*[1], T. Mueller[2]; [1]Ohio State University, Columbus, OH, [2]University of Tennessee, Knoxville, TN (472)

ABSTRACT

LEARNING OUTCOMES AND ASSESSMENT TOOLS. K. Renner*[1], T. Mueller[2]; [1]Michigan State University, East Lansing, MI, [2]University of Tennessee, Knoxville, TN (473)

ABSTRACT

LABS TO ENHANCE STUDENT LEARNING AND SHARING IDEAS ABOUT THEM. E. Hill[1], S. A. Clay[2], M. Bernards[3], T. Mueller*[4]; [1]Michigan State University, East Lansing, MI, [2]South Dakota State University, Brookings, SD, [3]Western Illinois University, Macomb, IL, [4]University of Tennessee, Knoxville, TN (474)

ABSTRACT